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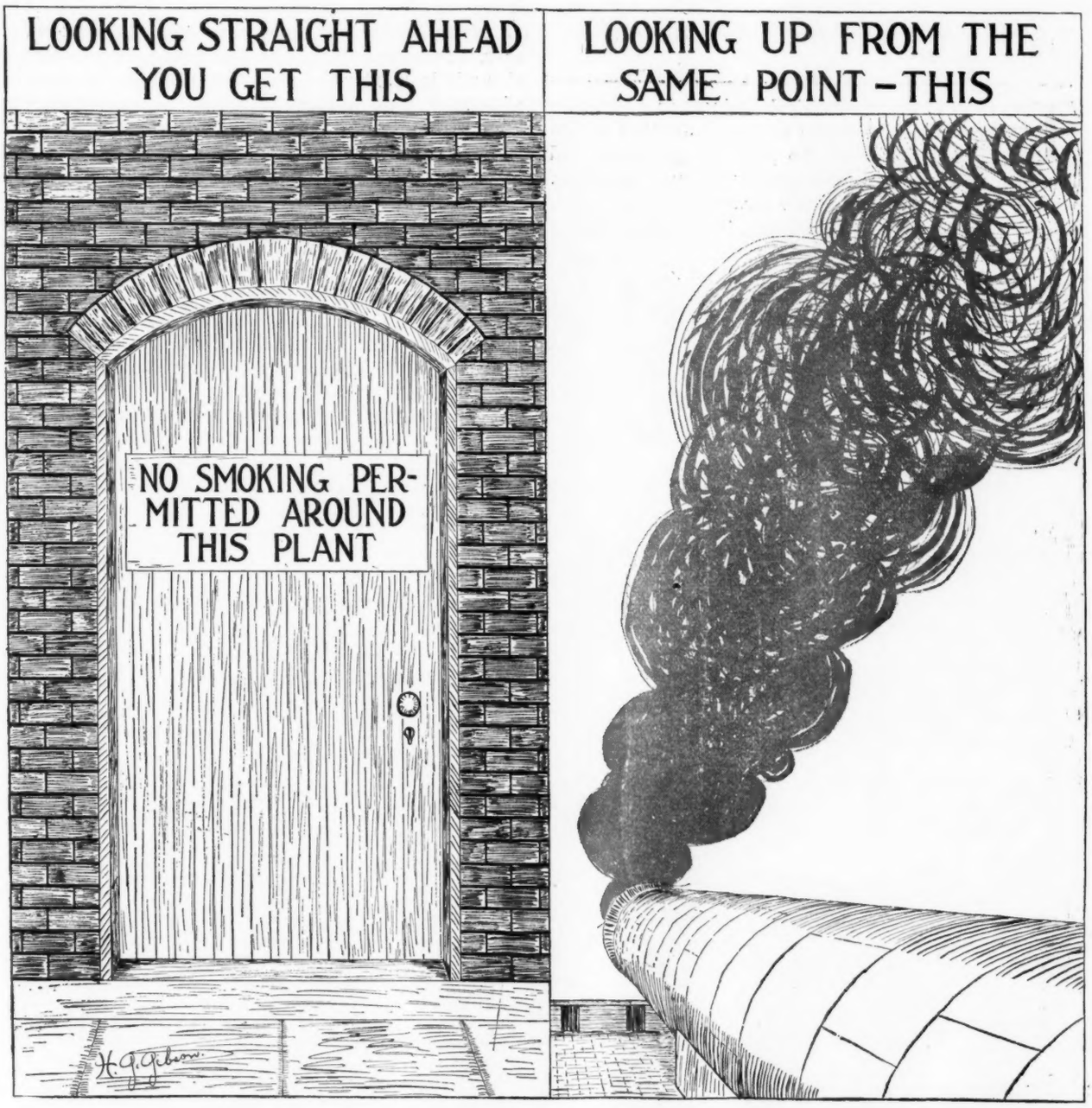

LOOKING STRAIGHT AHEAD YOU GET THIS
LOOKING UP FROM THE SAME POINT – THIS
NO SMOKING PERMITTED AROUND THIS PLANT
H. J. Gibson

Inexcusable Inconsistency

New Power Station at Albany

BY CHARLES H. BROMLEY

A model small central station of the new type, having no frills, but substantially built to give service and make money on the investment. Originally intended to act as a stand-by station for water power supplying Albany, Troy, Cohoes and adjacent territory, it has developed into what is likely to be the main generating station of the Municipal Gas Co.

TO BUILD up an electrical business in a city like Albany, N. Y., from an average daily load of less than 1000 kw. with the peak on maximum load less than 2000 kw., to a daily average of nearly 4000 kw. with a peak of now over 7000 kw., without putting a solicitor on the job to get business; to get as customers the leading hotels, which above all places should find an isolated plant a paying investment—to do these is to give service fairly and continuously. This is what has been done at Albany during the last ten years.

The old station at Trinity Place, Albany, was and is yet a reciprocating-engine installation, which served very well until the perfection of the steam turbine and until the company was able to get most of its power from the Adirondack Electric Power Corporation, which has a plant at Spier Falls, about 70 miles up the Hudson River and also from the hydro-electric station at Cohoes.[1] If a central station is to grow, or even hold its own, its service must be continuous. The public-service commission will look after the price to customers, but the kind of service is up to those who run the plant, therefore the desirability of a modern steam station at Albany to work in parallel with the Cohoes and Spier Falls plants in serving Albany, Troy, Cohoes and adjacent teritory.

The new station is situated on the Hudson River at the northern end of the city and on a site that is favorable for the development of factories. A paper mill will soon locate alongside and will not only take its power, but will get its steam, from the station. Fig. 2 is a view of the station. It is 150 ft. back from the dock line. The ground for 12 ft. down is ordinary dirt, the next 3 to 4 ft. is coarse gravel which lies on coarse black sand and rock. The building is of steel, concrete and brick. The boiler house is 118 x 48 ft., the turbine room 70 x 50 ft., and the electrical gallery 70 x 48 ft. Construction began in 1916, and today the station and grounds are completed.

Though in flood periods of the river the water may rise six feet above the ground level outside the building, this will not interfere with plant operation.

The reader will notice that the highest high-water level, due to flood of the river, is 22.4 ft., which is

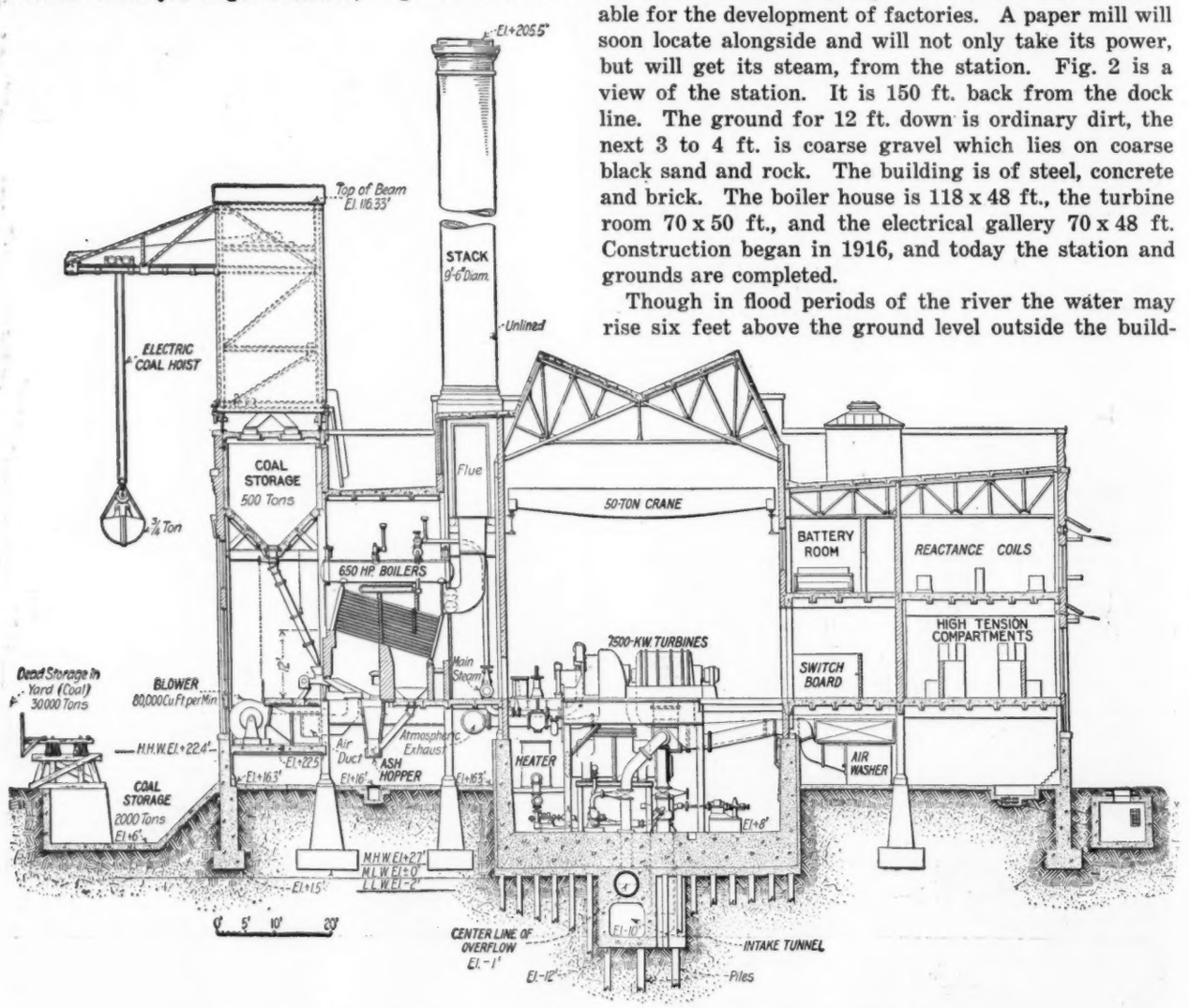


FIG. 1. SECTION OF THE RIVER STATION, MUNICIPAL GAS CO., ALBANY, N. Y.

[1]Described in "Power," Oct. 5, 1915, page 466.

within 10 ft. of the boiler-room main floor and about 14 ft. above the basement floor of the turbine room. The turbine-room basement is therefore inclosed in a waterproof concrete box. As this is one of the interesting features of the plant, details of it will be given. From Fig. 5, which is a part section, it will be seen that the floor of this "box" is 6 ft. in thickness, the waterproofing being 6 in. above the bottom and 6 in. in from the sides. The chief dimensions are given. Fig. 3 is a detail of the intake tunnel and suction wells. Half-inch square bars, each 15 ft. long, are placed at 6-in. centers around the intake tunnel to reinforce the concrete where the suction-well pipe terminates at the bottom; similar square bars have been bent around the suction well.

Notice that the waterproofing enters the flange in the section well, which is embedded in the concrete. A detail of the joint where the pipe pierces the waterproofing is shown in Fig. 4. A lead gasket fits the flange and extends for a distance of approximately 12 in. out from and all around the outside of the flange. Notice that the waterproofing incloses the part of the gasket that extends beyond the flange, three layers being on the bottom and two on the top, the waterproofing being bonded

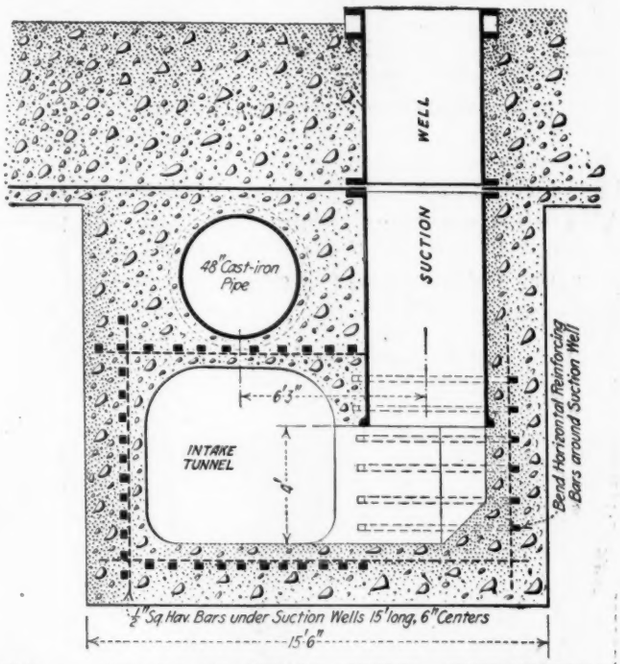


FIG. 3. DETAILS OF INTAKE TUNNEL, SUCTION WELL AND OVERFLOW, SHOWING REINFORCEMENT

to the lead gasket. The waterproofing material is impregnated felt.

Fig. 5 is a detail of the side walls showing the stack anchor bolts and plates, the waterproofiing and the reinforcement.

Fig. 6 shows a broken longitudinal section of the intake tunnel, the overflow pipe and the concrete "box." Notice that the intake tunnel may be reached from the rear through the manhole shown. This provision allows

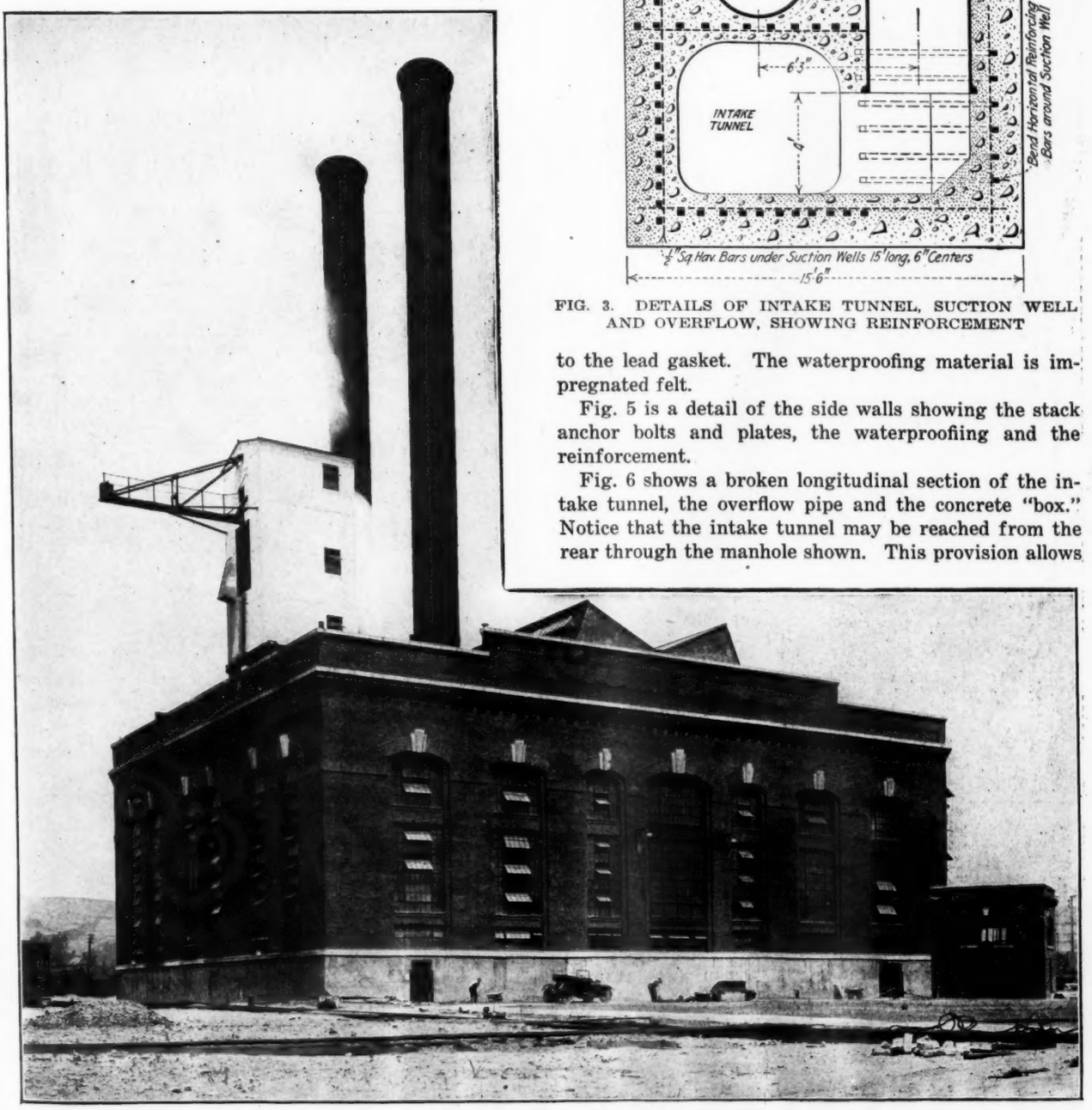


FIG. 2. THE RIVER STATION, ALBANY, N. Y.; SCREEN HOUSE TO THE RIGHT

the crew to get at the tunnel from both ends, which of course will expedite cleaning. Fig. 7 shows a section of the sump pit and connections.

Another interesting constructional feature of the plant is the interior walls of the turbine room. It is quite common practice nowadays to use an enameled brick, usually white. The writer was indeed impressed by the fine showing that an ordinary red-brick wall will make when the bricks are given a coat of filler and three coats of a good grade of mill white paint. Some idea of how well such a wall looks may be had from Fig. 9 and from the following incident: The president of an electric company in the Middle West, now building a large station, visited the Albany plant and was so impressed by the showing made by properly painting these red-brick walls, that he immediately decided to use red bricks for his station, instead of white enamel bricks as originally intended. The saving in a station of considerable size by the use of common red instead of enameled bricks amounts to quite a few thousand dollars. On the southern side of the plant (boiler-room side) is an outside concrete coal bunker of 2000 tons capacity. The concrete bunker above the boilers has capacity for 500 tons, and the yard affords storage room for 30,000 tons. Coal may be brought to the station in railroad cars, by river and by canal. Owing to flood of the river, all coal stored outside the station will at times be wholly or partly under water.

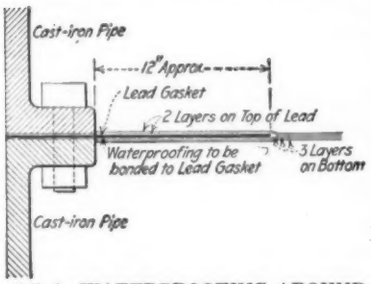


FIG. 4. WATERPROOFING AROUND JOINT IN SUCTION WELL

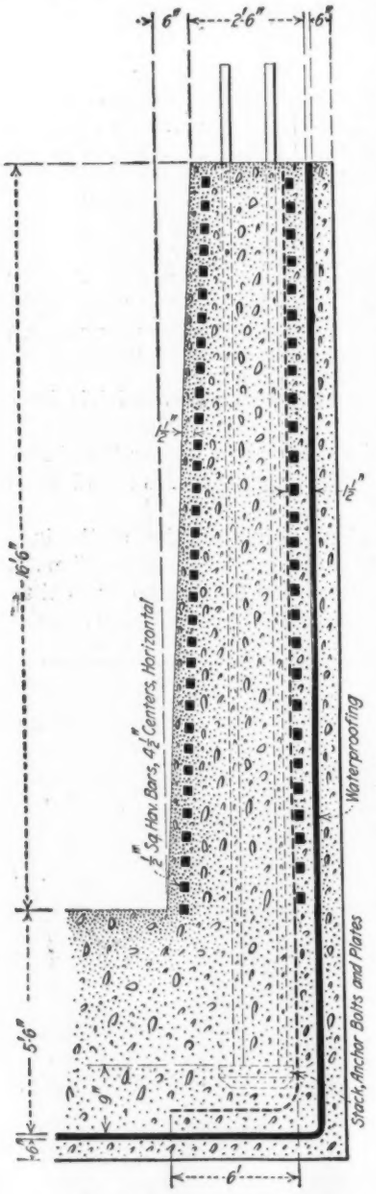


FIG. 5. DETAIL OF SIDE WALL

A movable electric coal-hoist tower will handle 45 tons per hour with a clamshell bucket of ¾-ton capacity.

The two stacks are of steel, each 174 ft. high above boiler floor, 9 ft. 6 in. diameter, unlined. This means, of course, that not only is the expense of lining eliminated, but the steel superstructure which supports the stacks may be made lighter than if the stacks were lined. This subject seems to afford interesting discussion, but unfortunately, space forbids going into it here, though *Power* hopes to publish the opinions of various engineers in the near future.

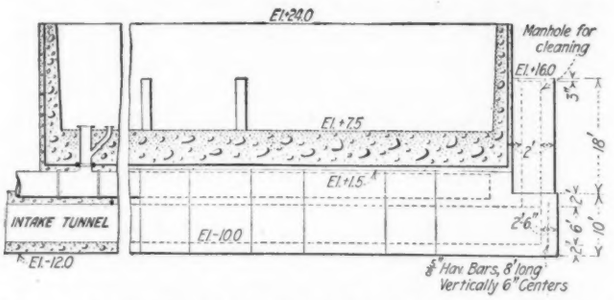


FIG. 6. LONGITUDINAL SECTION OF INTAKE TUNNEL; NOTE MANHOLE AT THE REAR

The boiler room, Fig. 8, which is unusually well lighted naturally, and ventilated, now contains five water-tube boilers, each having 6500 sq.ft. of heating surface, three 42-in. steam drums and 294 four-in. tubes each 18 ft. long. Each boiler was built for a pressure of 225 lb., but only 200 lb. is carried. Each boiler has a superheater of 943 sq.ft. heating surface. There is room for one more like boiler in the boiler house.

The stokers are of the underfeed type, each with seven retorts and each having 94 sq.ft. of active grate surface. The stokers are driven from a lineshaft by two 7 x 8-in. vertical engines. The engines run continuously at 190 r.p.m., and the stoker speed is varied by the use of a variable-speed drive connected to the lineshaft. The writer described this same type of drive as applied at the Waterside Stations, New York City, in *Power* for Nov. 17, 1914, page 698. The same drive arrangement is installed in the Two Hundred and First Street Station of the United Electric Light and Power Co., New York City. The bottoms of the front headers

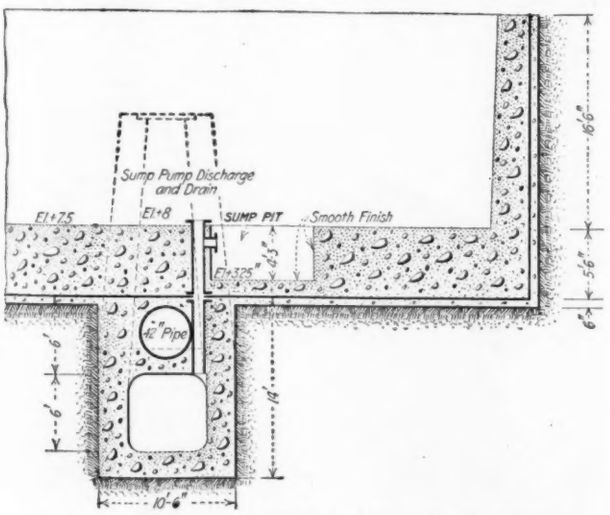


FIG. 7. SHOWING ARRANGEMENT OF SUMP PIT AND CONNECTIONS

of these boilers are 12 ft. above the floor, giving a high setting and large furnace volume.

There are two forced-draft fans, each of 80,000 cu.ft. of air per minute against a water presure of 7 in. Each fan is turbine-driven through gears, the turbine speed being 3540 r.p.m. and that of the fan 1182 revolutions.

The air pressure for the boilers is regulated by relieving or increasing the air-duct pressure upon a multi-diaphragm valve which controls steam to the turbines driving the blowers. The diaphragm regulator is simply a balanced valve actuated by the diaphragms, which in turn are moved by the air pressure from the duct. As the pressure on the diaphragms is much less than that necessary to move the valve controlling each of the turbines driving the fans, there must be considerable diaphragm area, especially if the valve is to be sensitive. Therefore a total area of approximately 70 sq.in. is used. A one-inch pipe connects with the air duct, coming out to an ell or a tee, one branch going to the diaphragm valve, the other going up through the floor alongside the combustion-control board and terminating with an ordinary one- or two-inch globe valve. As the diaphragm valve is actuated by the pressure in the air duct, it is evident that various pressures within the capacity of the fan may be carried in the duct by simply allowing a greater or lesser quantity of air to escape through the globe bleeder valve alongside the combustion-control board. This air pressure control was fully described and illustrated in the Nov. 17, 1914, issue.

A very large steam gage reading in increments of a quarter of a pound is placed at the end of the boiler room; its face is painted white, and it is well illuminated to make it easy for the fireman to observe a drop in pressure as soon as a drop begins. He can then immediately increase the air pressure and stoker speed and thus check the pressure drop.

From Fig. 1 the reader will see that the back chambers of the boilers are provided with chutes which empty into the ashpit below the boiler and from which the refuse may be loaded into small dump cars.

The boiler tubes are cleaned of soot by a hand lance blowing compressed air on the tubes.

There are two open feed-water heaters in the turbine-room basement, each rated at 6000 hp., but with capacity for 225,000 lb. of water per hour. Each has a water storage or content of 187 cu.ft. All auxiliaries exhaust into these heaters, which are vented to the atmosphere through two 10-in. pipes. A 14-in. relief valve is provided for protection against overpressure.

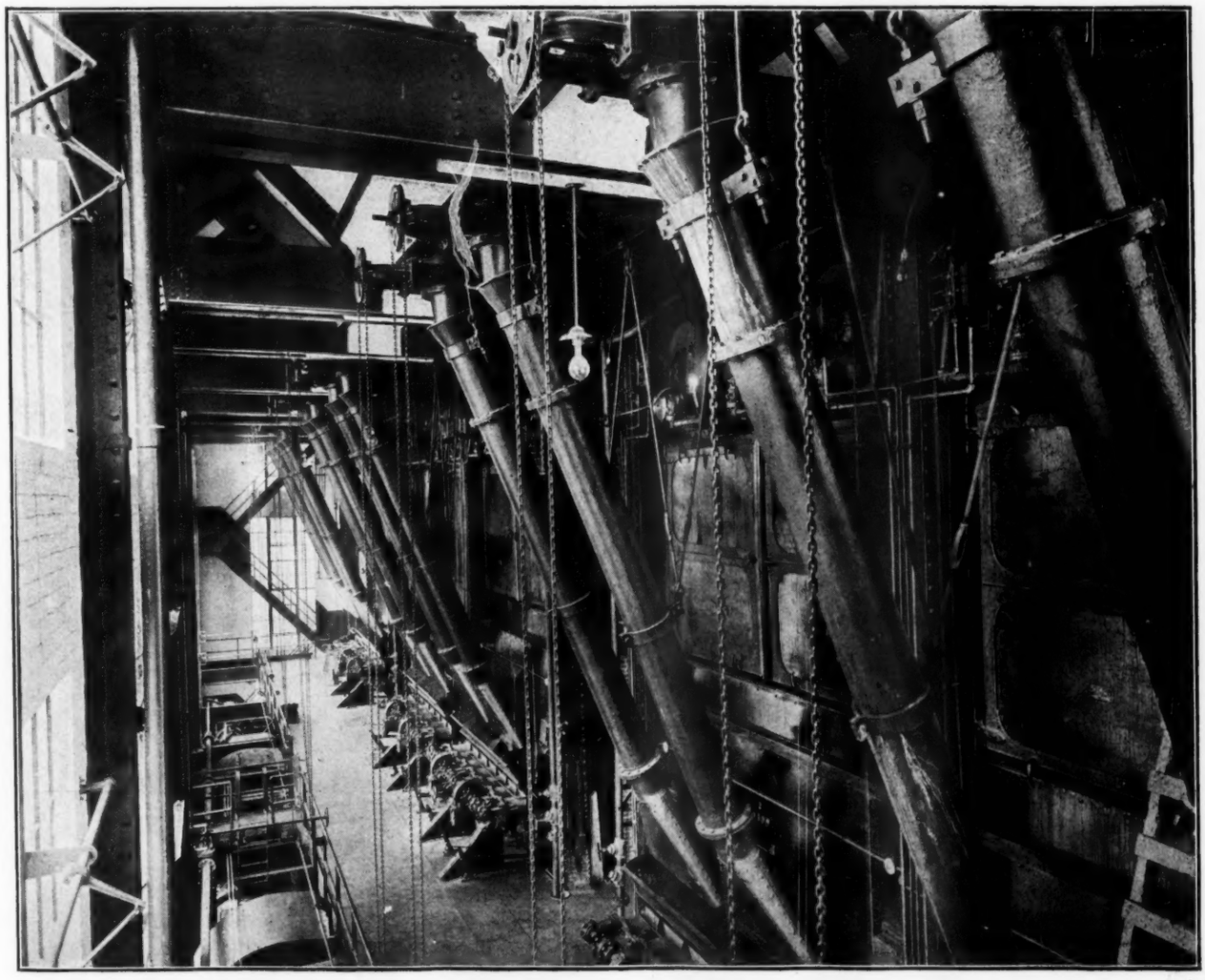


FIG. 8. RIVER STATION'S WELL-LIGHTED, VENTILATED AND EQUIPPED BOILER ROOM

The two feed pumps are of the 5-in. discharge, three-stage centrifugal type. Each is driven by a turbine of 116 hp., and at 3000 r.p.m. will deliver 500 gal. per min. against a pressure of 250 lb. The feed water is measured by an orifice meter. The feed mains in the basement are of cast iron, and all branches to the boilers are brass. Automatic feed-water regulators are used.

In the turbine room, Fig. 9, there are installed two 7500-kw. at 80 per cent. power factor, seven-stage 2400 r.p.m. 12,000-volt 40-cycle turbo-generators. Space for a future 15,000-kw. unit is provided. A feature being tried out on one of the turbines is the use of an extra oil-circulating pump, turbine-driven and so connected as to circulate oil through the bearings until the turbine is up to speed, at which time the usual pump geared to the governor shaft will be circulating an adequate quantity through the bearings. (See Fig. 10.) The turbine-driven pump then stops automatically. A pressure-reducing valve in the discharge line from the turbine-driven pump is connected so that it will also act to start the pump if the oil pressure in the line drops.

This insures, as much as it is possible to do so, that loss of oil pressure, with its serious consequences, will not happen. Ordinarily, a small reciprocating pump, started and stopped by hand, is provided for building up the oil pressure until the turbine is up to speed and for maintaining it from the time the main throttle is closed until the turbine ceases to rotate. The oil filter for the turbines has a capacity for 200 gal. per hour.

The condensers are of the two-pass, surface type each with 8000 sq.ft. of surface in ¾-in. Muntz-metal tubes. The chief guarantee with each is to condense 105,000 lb. of steam per hour with water at 70 deg. F. Notwithstanding that this is a small condenser, this transmission performance is excellent.

Each condenser has one 24-in. circulating pump driven by a 117-hp. turbine through gears; the turbine speed is 2500 r.p.m. The condensate and air pumps for each condenser are both on one shaft driven by a turbine running at 2500 revolutions per minute.

The turbine room contains a 5-in. two-stage house pump, turbine-driven. It will deliver 500 gal. per min. against 100 lb. and may be speeded up to get 150 lb. pressure. The normal speed is 2500 r.p.m., and the pump requires 48 hp. to drive it at full load for the lower pressure.

There is an automatic motor-driven 2½-in. vertical sump pump in the turbine-room basement for handling ordinary low-pressure drips which run to the sump. In the same sump there is arranged a 12-in. turbine-driven pump to be used in emergency. So far, the basement has been tight under flood conditions.

Air washers are installed in the basement of the electrical galleries for cleaning and cooling the ventilating air supplied to the main generators. Each 7500-kw. generator requires 30,000 cu.ft. of air per minute. The air delivered by the washers is at about 100 per cent. saturation. The air is taken from the basement of the electrical galleries, and sufficient window space is provided in this part of the building to insure a plentiful supply without unduly lowering its pressure. The air movement is obtained by fan blades mounted on the generator shafts, so that the washers operate on a draw-through system. One of the washers is shown in detail in Fig. 11. It consists of a sheet-metal casing approximately 15 ft. x 6 ft. 7 in. x 5 ft. 9 in., inside of which are two inclined baffles and a series of vertical eliminator plates. In the bottom of the casing water is kept at a constant level. Provision is made for flushing the washer free of dirt.

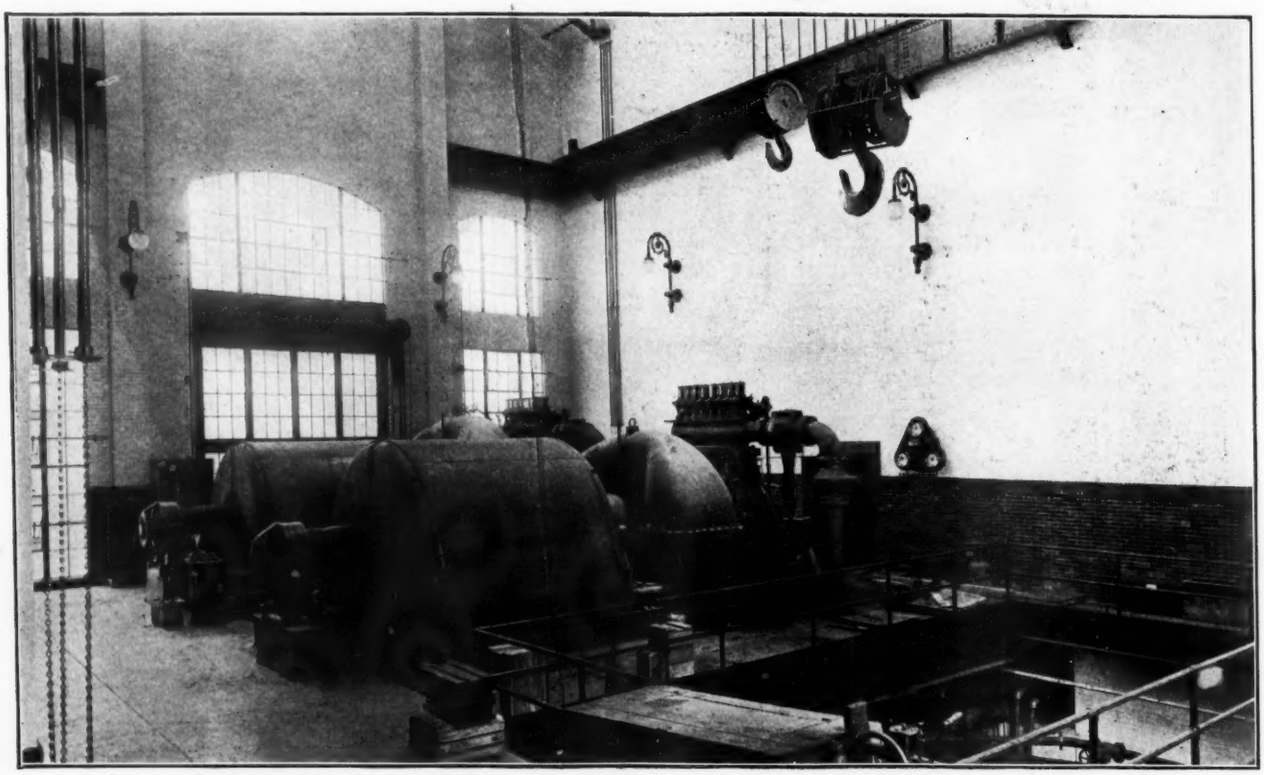


FIG. 9. TURBINE ROOM; TWO 7500-KW. UNITS, WITH ROOM FOR ONE 15,000-KW. MACHINE

When the air enters the washer, it strikes against a film of water maintained on the inclined baffles by means of perforated pipes at the top of the baffles. Because of the sharp change in direction which the air takes and its impingement on the water film, the solid content is washed to the bottom of the washer. A further impinging effect is produced against the surface of the water in the bottom of the casing, toward which the air is directed vertically downward. The air then passes through a nest of eliminator plates which remove any free entrained water carried along by the air. The eliminators are of the ordinary zigzag type.

Water is circulated from the bottom of the casing to the inclined baffles by means of a motor-driven centrifugal pump. The constant water level in the bottom is maintained by means of a float valve and overflow pipe. The washout connection goes to the main house-drain.

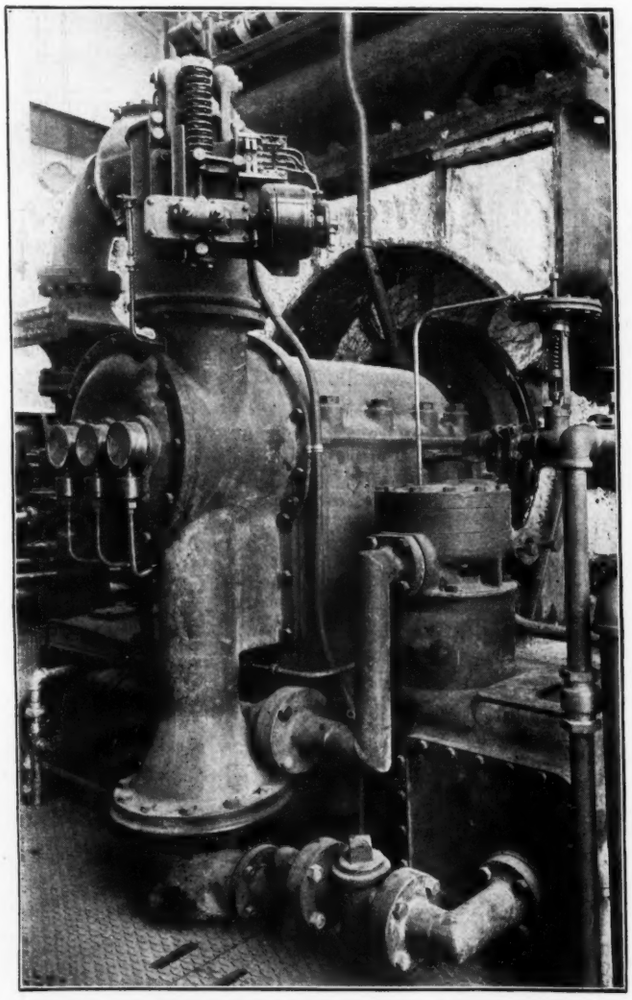


FIG. 10. TURBINE-DRIVEN CENTRIFUGAL OIL PUMP TO BE USED FOR STARTING AND STOPPING TURBINE

The air, after leaving the washer, passes to the duct leading directly to the generator. It circulates through the generator and passes to a discharge duct in the electrical-galleries basement, which discharges the air from both machines to the atmosphere. This discharged air, which is hot, may also be drawn in by the fans that supply air for combustion in the boiler furnaces.

An 8½ x 12-in. motor-driven reciprocating air compressor is used for supplying air for cleaning boilers, generators, switches, etc. It is in the basement of the turbine room.

The piping for superheated steam has extra-heavy steel fittings and valves. The boiler leads have automatic nonreturn valves. The main header is on the floor back of the boilers, the leads to the turbines being long-radius bends. Each main unit has a 24-in. atmospheric relief valve which leads the discharges into the main atmospheric-exhaust line. The expansion joints between the turbines and condensers are of copper.

IMPORTANT DATA OF RIVER STATION (ALBANY, N. Y.) AND LIST OF EQUIPMENT

These data show what ratios, proportions, velocities, etc., have been used in the design of this station. The capacities are calculated from specification or guarantee figures. Unless otherwise specified, all ratios, both terms of which relate to boilers and kilowatt capacity, are based upon 15,000 kw., and five 650 boilers.

Boiler Room	
Type of boilers	Babcock & Wilcox, three-drum water-tube
Number	5 at present, 6 ultimately
Heating surface, each, sq.ft	6,500
Superheater surface, each, sq.ft	943
Grate surface, active, each, sq.ft	94
Heating surface per square foot grate surface, sq.ft	69.1
Heating surface per square foot superheater surface, sq.ft	69
Superheater surface per square foot grate surface, sq.ft	1
Heating surface per kilowatt, sq.ft	1.804
Working pressure, lb. gage	200
Superheat, deg. F	100–150
Total steam temperature, deg. F	488 to 538
Stokers, Taylor underfeed, retorts per boiler	7
Stoker drive	Sturtevant engine, Reeves variable speed
Boiler-room coal bunker, nonsuspended, steel frame, concrete lined, capacity, tons	500
Boiler-room bunker capacity per square foot grate, tons, 1.56; lb.	2,130
Outside coal bunker, concrete, capacity, tons	2,000
Coal storage in yard, capacity, tons	30,000
Coal hoist: Builder	Mead Morrison
Coal hoist, electric, ¾ ton bucket, capacity per hour, tons	45
Coal-hoist capacity per sq.ft. grate surface, lb. per hr	160
Feed pumps, 2 Jeansville centrifugal, turbine (Terry) driven. Capacity, gal. per min., each	500
Feed water measured by Bailey orifice meter.	
Feed-pump capacity per square foot heating surface, gal. per min	0.0307
Feed-water heaters: 2 Cochran horizontal rectangular, rated capacity each, hp., 6,000; lb. water per hr	225,000
Feed-water heater, rated capacity per square foot boiler-heating surface, hp	0.37
Chimneys: 2 steel unlined. Height above boiler floor, ft. 174; diameter, ft	9.5
Chimney cross-section area per square foot grate, sq.ft	0.251
Forced draft fans: 2 Buffalo Forge Co.'s, turbine (Westinghouse) driven, geared; capacity each against 7 in. water pressure, cu.ft. per min	80,000
Capacity per square foot grate, cu.ft. per min. (both fans and 5 650-hp. boilers)	340
Turbines	
Two, 7,500-kw. at 80 per cent. power factor installed; space for one 15,000-kw.	
General Electric Co., single cylinder horizontal seven-stage, three-phase 40 cycle, speed, r.p.m	2,400
Operating pressure, lb	200
Operating superheat, deg. F	100 to 150
Performance guarantees: Operating condition—215 lb. abs., 100 deg. F. superheat, 1 in. abs. pressure, 30 in. barometer, in condenser: Net Kw. Load on Generator 7,500 — Lb. of Steam per Kw.-Hr. 12.5	
Total weight each turbo-generator, lb	230,000
Weight per rated kilowatt capacity, lb	30.6
Heaviest piece to be lifted by crane, tons	64,000
Turbine rated capacity per square foot floor space, outside measurements, kw	22.5
Exciters, one 100-kw. separate from main turbines, one of 55-kw., each on each main unit shaft.	
Oil filters, one, Richardson-Phenix Co., capacity, gal. per hour	200
Condensers	
Builder	Westinghouse Electric and Manufacturing Co.
Total tube surface per condenser, sq.ft	8,000
Tube area per kilowatt turbine capacity, sq.ft	1.06
Tubes	¾-in. Muntz metal (60 per cent. copper, 40 per cent. zinc)
Circulating pumps, 2 Westinghouse centrifugal turbine, gear-driven; capacity each, gal. per min	10,600
Vacuum pumps, 2 LeBlanc (vacuum pump and hotwell pump on one shaft, turbine-driven), speed, r.p.m	2,500
Miscellaneous	
Automatic stop valves on boilers	Foster
Automatic feed-water regulators	Copes
Air washers for generator ventilation	Metropolitan Engineering Co.
Main crane, 50-ton	Whiting
Coal hoist, 45 tons per hour	Mead Morrison Manufacturing Co.
House service and fire pump, Jeansville, Westinghouse turbine-driven, gal. per min	500
Sump pump, 1 Lea-Courtney, vertical, Terry turbine-driven, gal. per min	4,000
Sump pump, 1 Buffalo, vertical, General Electric Co., motor driven, gal. per min	250
Air compressor	Laidlaw-Dunn-Gordon
Atmospheric relief valves, two 24-in	Atwood & Morrill
Steam and water valves and piping	Walworth Manufacturing Co.
Electrical equipment	General Electric Co.
Reactance coils	Metropolitan Engineering Co.
Foundations and tunnels	Peter Keeler Building Co.
Steelwork	Vevering & Garrigues Co.
Superstructure	George A. Fuller Co.

The auxiliary piping is of the loop arrangement to insure steam to the auxiliaries in the event of accident or repairs to the piping.

The high-pressure drips are collected and discharged into the mud drums of the boilers by means of two reciprocating pumps. The low-pressure drips are discharged to the feed-water heaters by traps.

The main switchboard, Fig. 12, is of the remote-control type. The busses are of the ring type, of 2½-in. outside-diameter copper tubing. There are twelve 12,000-volt three-phase 40-cycle feeders—six incoming, six outgoing. Excitation is from a 250-volt direct-current bus through field rheostats. This bus is fed from one 100-kw. steam-driven exciter and two 55-kw. exciters mounted directly on the shafts of the 7500-kw. turbines. The step-down transformer bank consists of 1000-kv.-a. three-phase 12,000/2400-volt water-cooled, V-to-delta connected transformers. Unusual care has been taken in the station lighting to provide for any emergency. The secondary leads of one of the 40-kw. 2400-240-120-volt lighting transformers are carried to one side of a double-throw knife switch on the light and power switchboard, to the other side of which an emergency 240-120 volt alternating-current feed from the plant at Trinity Place is connected, this switch feeding into a three-wire single-phase lighting bus. Normally connected to this bus through one side of a 100-ampere automatic double-throw low-voltage release switch is an emergency lighting bus, the other side of the switch being connected permanently across the 600-ampere, or 240-120-volt storage battery. When the voltage on the main 240-120-volt alternating-current lighting bus falls to 30 volts, this switch automatically throws over to the battery feed. These emergency bus distributing feeds are carried to lamps placed in parts of the building where the lights will be most needed in such an emergency. The station power banks consist of four 100-kw. transformers arranged so that one acts as a spare and can be thrown into service in case of trouble to any one of the other three by means of double-throw knife switches in the primary and secondary leads. The secondaries are carried to a 240-volt three-phase three-wire bus at the light and power switchboard, from which both light and power feeders are distributed as follows: Eight for regular lighting, 3 for regular and emergency lighting, and 11 for power.

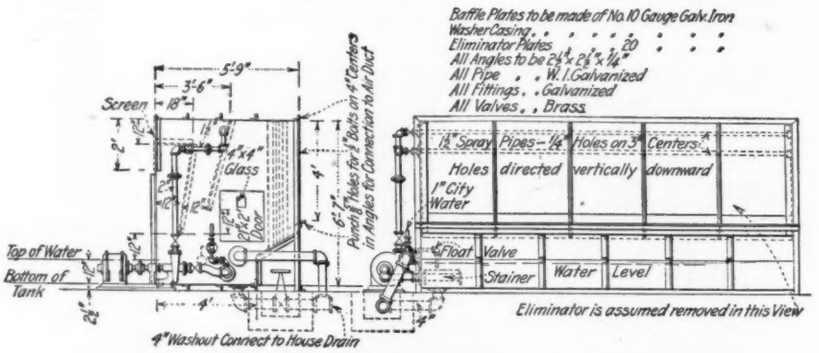

Baffle Plates to be made of No. 10 Gauge Galv. Iron
Washer Casing, ...
Eliminator Plates 20
All Angles to be 2½ x 2½ x ¼"
All Pipe . . W. I. Galvanized
All Fittings, . Galvanized
All Valves, . Brass
Screen
5'-9"
3'-6"
18"
4"x4" Glass
Door
Punch Holes for 3" Bolts on 4" Centers in Angles for Connection to Air Duct
¼" Spray Holes
Pipes—¼" directed
Holes on 3" vertically
Centers downward
1" City Water
Top of Water
Bottom of Tank
Float Valve
Strainer
Water Level
Eliminator is assumed removed in this View
4" Washout Connect to House Drain

FIG. 11. ELEVATIONS OF METROPOLITAN AIR WASHER

The station is one of the finest small plants built, and the best the writer has had the pleasure of visiting. It was designed by Thomas E. Murray, consulting engineer, New York City, and the construction was done under the supervision of Alexander Anderson, general manager, electrical department, Municipal Gas Co.

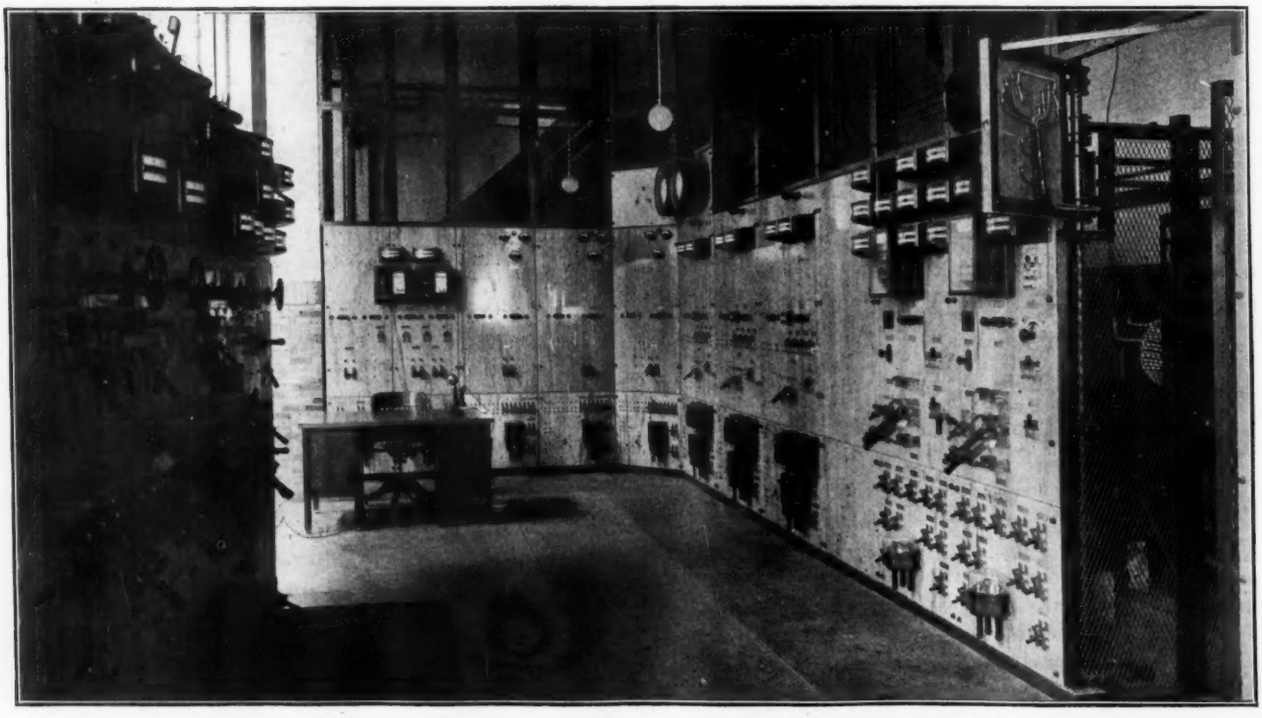


FIG. 12. THE REMOTE-CONTROL SWITCHBOARD, RIVER STATION

Tom Hunter, Hoisting Engineer

By WARREN O. ROGERS

Rain keeps us indoors, but Hunter tells how a telltale can be made to show from a distance whether a centrifugal pump is running. He also explains how a sump was built so that the accumulation of iron ore could be flushed out without stopping the pump, also how to make a pump-room water-tight, with means for the escape of the pumpman in case water flooded the mine. A method of lowering insulated electric cables down a shaft and how to balance a skip when sinking a shaft are also explained.

RAIN was beating against the windows of my room the next morning when I awoke, and one look at the dark driving clouds made it evident that the mines were out of the question for the day. Hunter must have thought so too because he didn't show up until the last call for breakfast. When he had finished, we went to his room, one of the few that seemed to be heated at that time of the year.

"Nothing doing today," said he, as sheets of rain dashed against the window. "I guess we will camp here until things brighten up somewhat. By the way, how did the pictures come out that you took yesterday?"

"Very good," I replied, "although the conditions were not of the best."

"I suppose you took a picture of that little motor-driven pump that supplied the air compressor with oil?"

"Yes, I got it, although I don't know just why, as it seems to be exactly like a lot of others I have seen."

"It is," replied Hunter, "with one exception, and that is the little home-made telltale the operator has rigged up so that he can tell from a distance whether the machine is running or not. Your photograph will show that a metal disk," see Fig. 1, "about 2½ in. in diameter, is secured to a short piece of small round-iron rod, the ends of which are pointed. One end of the disk rod is set in a deep center-punch hole in the edge of the pump-bearing casting. The other end fits in a similar punch mark in the flattened end of a rod that is secured to the piping of the pump. The adjustment is such that the disk and shaft revolve freely in the center-punch bearings.

"The disk is set at an angle to get it as near the shaft coupling as possible, so that the air currents created by the revolving coupling will revolve the metal disk. When the operator looks at the machine, it is difficult to tell whether it is running or not, but the revolving disk is a sure indicator."

"Speaking of pumps," said I, at the same time moving closer to the radiator, "there does not seem to be so much water in iron mines to take care of as in coal mines."

"No; most iron mines are dry as compared with coal mines. There have been some rather interesting stunts pulled off first and last in relation to taking care of mine water.

"In mines where soft ore is taken out, the sump will naturally collect considerable ore that comes to it in the form of mud with the water. In one instance the pumping station was on the 1000-ft. level, and the sump was made with a concrete baffle wall, separating it into two compartments. Water came into the sump through a 7-ft. square drift to one side of the baffle, which, by the way, was lower than the top of the sump pit. I'll make a sketch of the layout so you will understand it more clearly." See Fig. 2.

"You see, when the water in the part *A* reaches the top of the baffle, it overflows into *B*, in which is the suction pipe of the pump. By this arrangement the iron ore was deposited in the chamber *A*. It had one fault, however, in that it required time to clean the iron ore from the intake side of the sump and if the water was diverted to the compartment *B* while cleaning out *A*, iron ore would get in section *B* and into the pump.

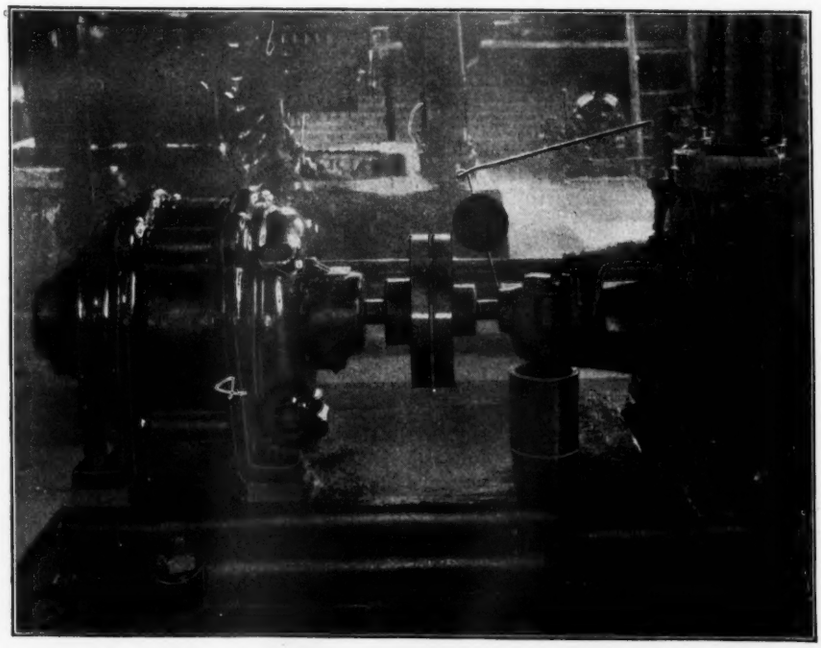


FIG. 1. TELLTALE ON CENTRIFUGAL OIL PUMP

"The difficulty was remedied by making a tunnel *C* tapping into the compartment *A* of the sump at the bottom. A branch tunnel *D* was carried to section *B* of the sump. These tunnels dropped to a level 60 ft. below the pumping station and bottom level of the mine. The outlet end of the sump tunnel was blocked with concrete embedded in the rock through which the tunnel was run. An 8-in. pipe was put in place before the concrete was poured, thus making an opening from the tunnel to the shaft. Just outside of the concrete wall

an 8-in. gate valve was put on the pipe, and on the end of the pipe a molasses-gate type of valve was placed. This valve was of the same design as those seen on molasses barrels in country stores and was easily adjusted to any point up to full opening and was for quickly opening and closing.

"When it was desirable to clean out the sump, the 8-in. gate valve was opened and an empty skip lowered so that the top was below the outlet of the 8-in. pipe. Then the molasses valve was opened, and the accumulation of iron ore was drawn from the sump into the skip and hoisted to the surface and dumped to mingle with the regular run of ore. The 8-in. gate valve was used only to make a tight shutoff and was kept closed except when draining the sump."

"Well, that looks like a good stunt, but I'll tell you one thing, I would not want the job of tending a mine pump with no one to talk to or see except when some one happens to drop in. Just think what would happen if the mine got flooded by the miners striking a pocket of water."

"Water pockets are encountered, and they sometimes flood the pumproom and lower pits of the mines, because the pump is not of sufficient capacity to handle the excess volume. While there is no way to prevent striking

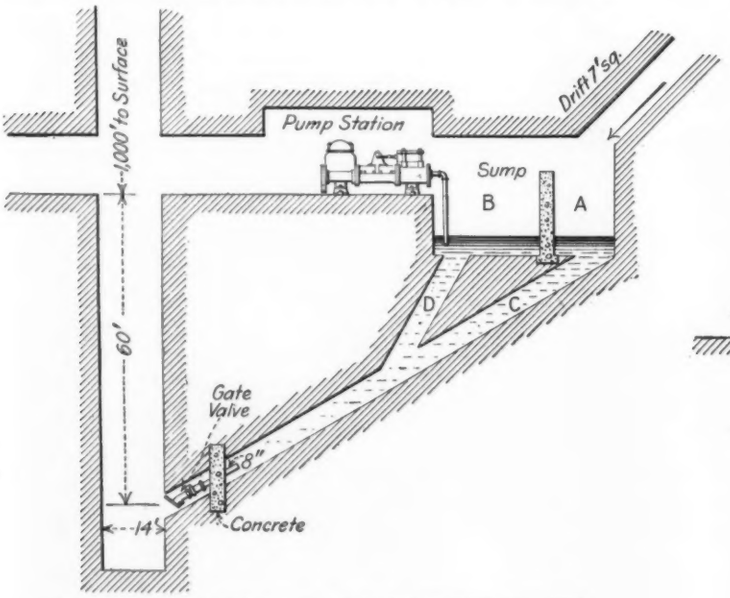


FIG. 2. SUMP BAFFLE AND CLEANING-OUT TUNNEL

water pockets, there is a way to prevent the flooding of the pumproom."

Hunter stopped talking long enough to light his pipe and then said: "In one instance I know of, the entry to the pumproom was stopped with a bulkhead of cement and fitted with a water-tight door. This door was close to the shaft, and the layout of the idea as carried out was like this," and Hunter drew a sketch similar to Fig. 3. "A 10-in. water pipe from the mine to the sump ran through the bulkhead, but was made water-tight. From the lower level to the level above an uptake was cut and fitted with a ladder."

"What was the idea of the ladder?" I asked. "Was the pumpman expected to climb from one level to the other?"

"That was just it. In case a water pocket was encountered of greater volume than the sump pump could take care of, the bulkhead door would be closed, which would shut off the pumproom from the lower part of the mine. In case the water should come into the mine fast enough to flood it, up to the upper level, the pump runner could escape up the ladder. The uptake would

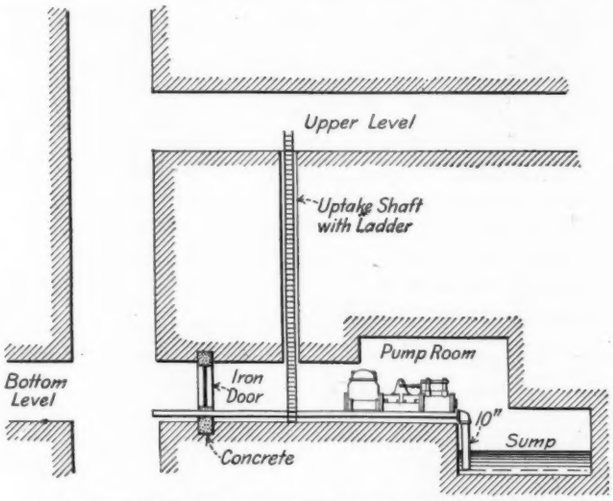


FIG. 3. PUMP ROOM PROTECTED FROM WATER BY CONCRETE BULKHEAD

also serve as a means of sending down food and supplies."

While Hunter was talking, the storm had increased in violence, and as I watched the swinging of the electric-light wires on the street poles, one of them suddenly broke, owing to the strain, and this set me to think-

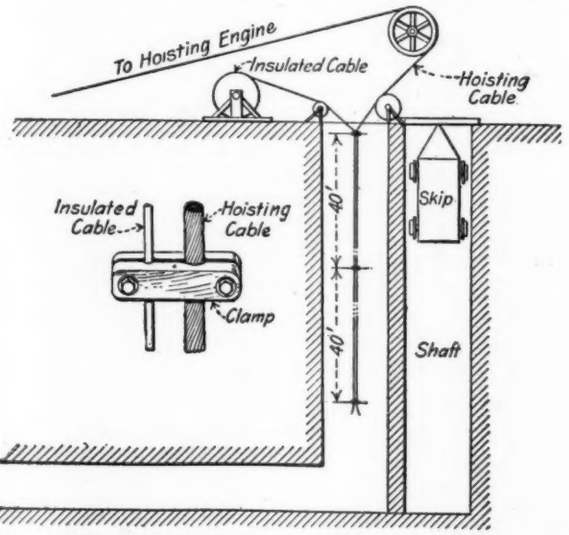


FIG. 4. METHOD OF LOWERING INSULATED CABLE DOWN A MINE SHAFT

ing of the strain that must come on electric wires when they are being lowered into the mine shaft. I put the question to Hunter.

"Of course you take it for granted that it is an easy matter to put an electric cable down a mine shaft. On the contrary, it is quite a job, because there is danger of damaging the insulation, and if that occurs, trouble will result. In putting in an electric cable the difficulty comes because of the weight of the cable as it nears the bottom of the shaft. This weight would all come on the cable where it ran over the sheave wheel at the top of

the shaft, and the weight of a long length of cable would be liable to break the insulation.

"One way of doing the job, and one that has worked satisfactorily, is to hoist a skip to the top of the shaft and unfasten the hoisting rope from it and lower it down the other side of the shaft, the cage of which is, of course, at the bottom. The end of the electric cable is clamped to the end of the hoisting rope and the whole lowered about 40 ft., when another clamp is made with the cables. The whole is then lowered another 40 ft., and so on until the end reaches the bottom of the mine shaft, with enough length to carry to one side for terminal connections." To illustrate the idea Hunter made the sketch shown in Fig. 4.

"When the electric cable has been lowered as far as desired, the top of the cable is secured in place to one side of the shaft and the top clamp is then removed. The weight of the cable will straighten it out, and it is secured in place at suitable distances until the next

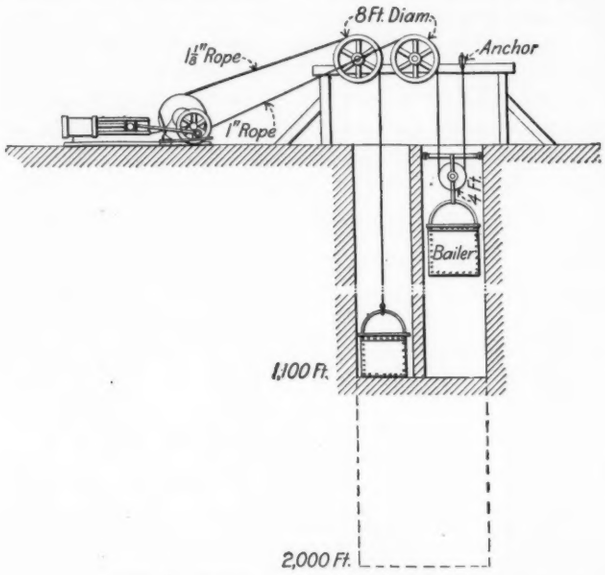


FIG. 5. BALANCING A SINKING SKIP

clamp is reached, when it is removed. In this way an insulated cable can be put in place without injury."

"Say, that is a pretty good way, especially for a deep mine. I suppose such methods are common with these mining fellows."

"Just the same as with any other business. They all have interesting ways of doing things. Take, for instance, the sinking of a new shaft. It is a whole lot different from digging a well or going down in the shaft of a shallow mine. When sinking a deep shaft, the weight of the skip and cable becomes an item in the hoisting load and interferes with the speed of getting the rock out.

"In shaft sinking there is but one skip, and of course it is not counterbalanced with a second one as in the case of the average shaft under ordinary practice.

"The weight of the skip was counterbalanced in one instance by utilizing a mine bailer. I guess I had better make a sketch so that you will understand just how the thing was arranged." See Fig. 5. "The 1⅛-in. cable to the skip ran over the drum on the hoisting engine, and the 1-in. one from the bailer ran to the under side, both going over sheave wheels of 8-ft. diameter. The cable to the bailer, however, ran over a 4-ft. wheel to an anchor to which the end of the rope was secured. This arrangement gave the skip twice the travel that the bailer had. In this way the rock skip was balanced and as the shaft was deepened the cable on the bailer was lengthened to give it freedom of movement in the shaft."

Girtanner Chain-Grate Links

In overhauling a chain grate it is better to take off the entire chain and put in new links throughout. The best of the old links can then be utilized to make up the deficiencies in the next grate. In this way links of

FIG. 1. STANDARD CHAIN-GRATE LINK

the same design and quality of material are used in each stoker. The removal of the chains also permits overhauling the rollers on which the links travel or any other part of the equipment.

Fig. 1 shows a standard link with 4½- or 5-in. centers and fire surfaces 1¼, 1½ or 1¾ in. wide, made by the Fred Girtanner Co., Chemical Building, St. Louis, Mo. The fire surface of the link is slotted to give an air space of 36 per cent., and depending upon the

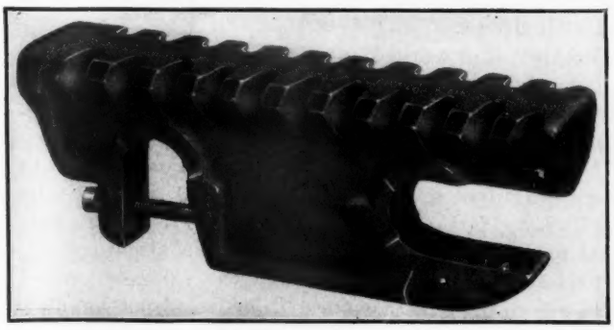


FIG. 2. CHAIN-GRATE REPAIR LINK

length of the rollers between the links, separating the top surfaces from $\frac{1}{16}$ to $\frac{1}{8}$ in., this air space is somewhat increased. Other distinguishing features are corrugations in the surface of the link body to give greater cooling surface and slots in the hubs and rollers separating the links to keep the rods cool. The links may be applied to any chain-grate stoker by changing the driving sprockets and idlers.

A repair link of the same general design is also made. As shown in Fig. 2, it has an open horizontal slot at the rear and a vertical slot at the front with a screw to hold the link on the rod. These links can be put into place while the stoker is in operation. The old link is first removed and at the next revolution of the grate the new link is inserted.

The Electrical Study Course—Effects of Internal Resistance

The effects of the resistance of the source of electromotive force is considered, and problems are worked out showing how this resistance affects the results obtained in the external circuit.

IN THE previous lesson it was shown that the normal open-circuit voltage of a battery cell was not the pressure that would exist when the battery was supplying current to an external circuit, and although the electrical pressure was produced in the cell, part of this pressure is used up in causing the current to flow through the source, owing to the internal resistance.

In study problem 1 of the last lesson the cell in question had internal resistance $r = 0.4$ ohm and a normal voltage E of 1.8 volts. Fig. 1 shows this cell connected to a bell having a resistance R_1 of 2.6 ohms, as called for in the problem. The total resistance of the bell and the battery cells is $R = R_1 + r = 2.6 + 0.4 = 3$ ohms, the current $I = \frac{E}{R} = \frac{1.8}{3} = 0.6$ ampere, and the voltage across the bell terminals is $E_1 = R_1 I = 2.6 \times 0.6 = 1.56$ volts. The difference between this latter value and the open-circuit volts will give the volts e necessary to cause the current to flow through the battery; that is, $e = E - E_1 = 1.8 - 1.56 = 0.24$ volt. Or, by Ohm's law, $e = rI = 0.4 \times 0.6 = 0.24$ volt. Here we find that Ohm's law may be applied equally as well to finding the volts necessary to cause the current to flow through the internal resistance of the source of voltage as to the external circuit.

Problem 2 is worked out similarly to problem 1, the values of the former being given in Fig. 2. The total resistance R of the circuit is the sum of the resistance of the armature and the external circuit, or $R = r + R_1 = 0.25 + 4.75 = 5$ ohms. The voltage necessary to cause the curent to flow through the total resistance, by Ohm's laws, is $E = RI = 5 \times 35 = 175$ volts. This total pressure is not all effective at the armature terminals although 175 volts is what the voltmeter would read before the load is connected. A small portion of it is used to cause the current to flow through the armature. There are several ways that volts at the armature terminals may be calculated when the current is flowing. First, by Ohm's law, $E_1 = R_1 I = 4.75 \times 35 = 166.25$ volts. Second, the volts e necessary to cause the current to flow through the armature will be equal to the resistance of the armature times the current. This is found just the same as the volts necessary to cause the current to flow through the battery, problem 1. In Fig. 2, $e = rI = 0.25 \times 35 = 8.75$ volts, and the difference between this and the total volts will give the volts effective at the terminals of the generator to cause the current to flow through the external circuit, or $E_1 = E - e = 175 - 8.75 = 166.25$ volts; this checks up with the values obtained by Ohm's law. The foregoing accounts for one of the causes why the voltage of a generator generally drops off slightly when load is applied; a small percentage of the total volts is used up to cause the current to flow through the armature.

The watts W_1 supplied to the load by the generator, are equal to the available volts E_1 times the current I; that is $W_1 = E_1 I = 166.25 \times 35 = 5818.75$; kilowatts $= \frac{W}{1000} = \frac{5818.75}{1000} = 5.8$ kilowatts and electrical horsepower $= \frac{W}{746} = \frac{5818.75}{746} = 7.8$ horsepower. The watts loss w in the armature is equal to the volts drop e through the armature times the current I, or $w = eI = 8.75 \times 35 = 306.251$ watts. Another method of obtaining the watts loss in the armature is $w = I^2 r = 35 \times 35 \times 0.25 = 306.25$ watts. This 306.25 watts represents energy that has been supplied to the machine which is expended within the machine itself and appears in the form of heat. The total watts developed in the armature is $W = EI = 175 \times 35 = 6125$ watts, and the difference between this value and the watts supplied is also equal to the watts loss, or $w = W - W_1 = 6125 - 5818.75 = 306.25$ watts. From this it is seen that 6125 watts are developed in the armature, but only

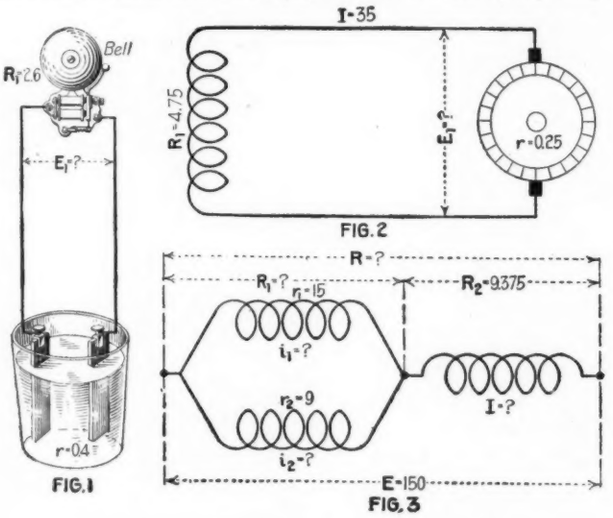


FIG. 1 FIG. 2 FIG. 3

FIGS. 1 TO 3. TYPES OF ELECTRICAL CIRCUITS
Fig. 1—Bell connected to a voltaic cell. Fig. 2—Resistance connected to a dynamo's armature. Fig. 3—Complex circuit

5818.75 are available at the load, 306.25 watts are lost in the armature, as explained in the foregoing.

The third problem is given in Fig. 3. The first element to find is $R_1 = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{1}{\frac{1}{15} + \frac{1}{9}} = \frac{1}{\frac{8}{45}} = \frac{45}{8} = 5.625$ ohms. Then the total resistance $R = R_1 + R_2 = 5.625 + 9.375 = 15$ ohms; and $I = \frac{E}{R} = \frac{150}{15} = 10$ amperes. The volts drop across R_1 is $E_1 = R_1 I = 5.625 \times 10 = 56.25$ volts; then $i_1 = \frac{E_1}{r_1} = \frac{56.25}{15} = 3.75$ amperes, and $i_2 = \frac{E_1}{r_2} = \frac{56.25}{9} = 6.25$ amperes. From this, $I = i_1 + i_2 = 3.75 + 6.25 = 10$ amperes, which checks with the values obtained by Ohm's law.

Referring to the problem Fig 1 and connecting a second bell in parallel with the first, as in Fig. 4, we will find that the volts E_1 will be less in the latter than in the former. The joint resistance R_2 of the two bells in parallel will be one-half that of one, or $R_2 = \frac{R_1}{2} = \frac{2.6}{2}$ $= 1.3$ ohms. This gives a total resistance R for the bells and battery of $R = R_2 + r = 1.3 + 0.4 = 1.7$ ohms. If the cell, Fig. 4, has an open-circuit voltage, $E = 1.8$ volts as in Fig. 1, the value of the current I will be $I = \frac{E}{R} = \frac{1.8}{1.7} = 1.06$ amperes, which will be divided equally between the two bells in parallel, or $i = \frac{I}{2} = \frac{1.06}{2} =$ 0.53 ampere, against 0.6 ampere flowing through the bells in Fig. 1.

The volts E_1 applied to the terminals of the bells are by Ohm's law $E_1 = R_1 I = 1.3 \times 1.06 = 1.378$ volts, against 1.56 volts in Fig. 1. Also the volts drop through the battery is $e = rI = 0.4 \times 1.06 = 0.424$ volt. The sum of these two values is $E = E_1 + e = 1.378 +$ $0.424 = 1.802$ volts, against 1.8 volts given. The difference of 0.002 volt is due to the value 1.06 amperes for the current being a little large. This is why one bell may ring satisfactorily from a battery, but when two are connected in parallel they may not ring from the same source.

What we have seen in reference to Fig. 4 also accounts for the reason electric locomotives and trucks operated from storage batteries will sometimes pull more when

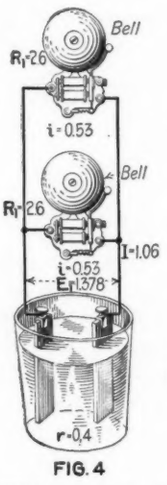


FIG. 4

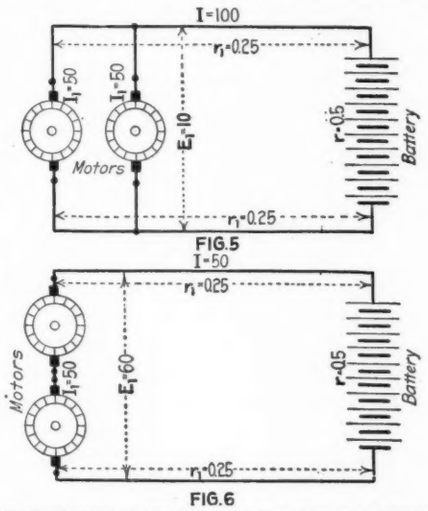


FIG.5

FIG.6

FIGS. 4 TO 6. DIFFERENT COMBINATIONS OF BATTERY AND LOAD CONNECTIONS

Fig. 4—Voltaic cell connected to two bells in parallel. Fig. 5—Battery connected to two motors in parallel. Fig. 6—Battery connected to two motors in series

the motors are connected in series than when they are grouped in parallel. For example, assume a condition where the resistance of the battery is 0.5 ohm, resistance of the wires connecting the battery to the motors 0.5 ohm, open-circuit volts of the battery is 110 and the current taken by the motors when connected in parallel 100 amperes. The total resistance of the battery and connecting wires is $R = r_1 + r_1 + r = 0.25 +$ $0.25 + 0.5 = 1$ ohm, and the volts drop due to the resistance of the battery and connecting wires is $E_2 =$ $RI = 1 \times 100 = 100$ volts drop; that is, 100 volts of the total 110 are used up to cause the current to flow through the resistance of the battery and the connecting wires, which will leave only 10 volts available at the motor terminals. The watts supplied to the motors are $W_1 = E_1 I = 10 \times 100 = 1000$ watts, or 500 watts to each motor, Fig. 5.

If the motors are connected in series, as in Fig. 6, only 50 amperes will have to flow in the line to have 50 amperes flowing through the motors. With 50 amperes flowing in the line, the volts drop due to battery and line resistance is $E_2 = RI = 1 \times 50 = 50$ volts. This leaves 60 volts available at the motor ter

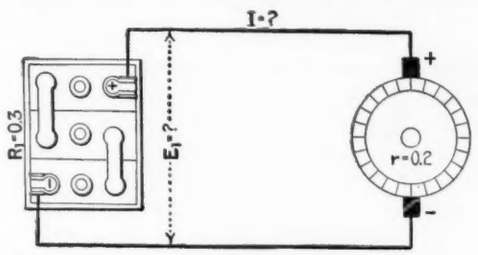


FIG. 7. BATTERY CONNECTED TO DYNAMO

minals when they are connected in series, and the watts supplied to the two motors in series is $W_1 = E_1 I =$ $60 \times 50 = 3000$ watts. Hence it will be seen that three times the energy is supplied to the motors when they are connected in series as when connected in parallel. In the first case the total watts given up by the battery is equal to the total volts times the total current, or $W = EI = 110 \times 100 = 11{,}000$ watts, and in the second case $W = EI = 110 \times 50 = 5500$ watts. This illustrates very clearly the necessity of keeping the resistance on the source of electromotive force and the connecting wires low if a large current is to be supplied. In the first case the battery gave up 11,000 watts, but only 1000 watts were supplied to the motors, the other 10,000 watts being lost in the connected wires and the battery, owing to their resistance. In the second case the battery supplied a total of only 5500 watts, but 3000 watts, or three times that in Fig. 5, were supplied to the motors, only 2500 watts being lost in the line and battery.

If the combined resistance of the line and battery had only been 0.5 ohm, in Fig. 5, the watts supplied to the motors in parallel would be 6000, and with the motors in series, as in Fig. 6, 4250. Here the conditions have been reversed; since the motors in parallel are supplied a greater wattage than when connected in series, they will do a greater work. It is, therefore, evident that the internal resistance of the source of electromotive force is an important factor and must be kept low if the voltage is to remain fairly constant; also the resistance of the connecting wires must be kept low if the voltage is to remain constant at the load. These elements have a direct bearing upon the size of conductors used to transmit a given current and will be treated in subsequent lessons.

In Fig. 7 the battery has a normal pressure between its terminals of 6 volts and an internal resistance R_1 of 0.3 ohm, which is connected to a dynamo that develops 10 volts across its terminals on open-circuit. The resistance of the armature is $r = 0.2$ ohm. Neglecting the resistance of the connecting wires, find the curent that will flow through the battery when connected to the generator, as shown in the figure, also the volts impressed on the battery terminals.

Wrought Iron and Steel Pipe Sizes

By A. J. DIXON

Between ordinary pipes of the various weights there is a wide difference in the actual internal diameters for the same nominal diameter, so that due allowance must be made when estimating the carrying capacity of the respective grades.

TRANSMISSION of steam, water, air, oil, ammonia vapor and the like is a fundamental operation in every power plant, and the ordinary means of transmission by wrought-iron or steel piping affords perhaps the most familiar sight among all the details of power-plant construction. Nevertheless, precise information regarding the dimensions and physical characteristics of the grades of pipe ordinarily used is not nearly so common among power-plant operators as is the commodity itself. This is a subject upon which every engineer should be well posted. It is not unusual for an engineer to run lengths of lightweight pipe, of the grade customarily known as "merchant," into a line that ought to be of standard weight throughout, simply because he cannot discriminate at sight between the two grades. [The manufacture of "merchant" pipe has been almost entirely discontinued.] Such lack of discernment in a matter so important is hardly excusable in any case, since tables giving all the dimensions pertaining to pipe sizes are readily procurable in handbooks and trade catalogs.

All Pipe Sizes Merely Nominal

Nearly every man employed in any kind of work that calls for the use of piping knows that the given size of a wrought-iron or steel pipe (up to and including 12-in.) generally refers to the inside diameter. But not every engineer is aware that the size mentioned is merely nominal; that it does not designate the actual size and means nothing more than a name to distinguish a particular pipe from the next larger or smaller in the series.

Standard wrought-iron or steel pipe of any size up to and including 10-in. is with three exceptions larger in diameter internally than its specific designation would indicate. Ordinary 1-in. wrought-iron pipe, for example, when made to conform exactly to standard dimensions (which, however, is not always the case) has an internal diameter of 1.05 in., which is $^1/_{20}$ in. over the nominal size.

On the other hand, extra strong pipe having a higher designation than ¼-in. and up to 12-in. is smaller in diameter, with one exception, than the nominal size would indicate. Thus, extra strong 1-in. wrought-iron pipe is 0.95 in. diameter inside, which is $^1/_{20}$ in. under the nominal size, while double extra strong 1-in. pipe has an actual internal diameter of only 0.60 in., or a little more than half the nominal value.

This is something that should be borne in mind when figuring the size of a pipe that is to have a certain discharge capacity. Suppose, for example, that in a job of piping designed to withstand uncommonly high pressure, as in hydraulic work where severity of service might make imperative the use of double extra strong pipe, and the computation shows that it requires an area of cross-section corresponding to a diameter of 1 in. If in this case the engineer proceeds on the assumption that double extra strong pipe nominally rated as 1-in. will even approximately meet the requirement, he may find himself greviously in error. The discharge capacities of pipes vary approximately as the squares of their diameters. Therefore, while a standard 1-in. pipe would give the needed capacity with something to spare, since its inside diameter is slightly in excess of 1 in., a double extra strong pipe of the same nominal size would be prohibitively scant, since its discharge capacity would be barely more than one-third of the calculated value. The pipe that should properly be used in this case would be 1½-in. double extra strong, since this size has an actual inside diameter of 1.10 in., which is but a fraction in excess of standard 1-in. pipe.

Variation from Size Greater in Small Pipe

This disparity between the actual and the nominal diameters is especially observable in the small sizes of iron pipe. If pains be taken to carefully cut out the burr made in cutting through a piece of ⅛-in. standard pipe, it will be found that the bore actually measures a trifle more than ¼ in., the value given in the table being 0.27 in., which is more than twice the nominal size. This anomaly is apparently due to the necessity of having the inside diameter of the standard pipes large enough to insure a sufficiently large bore when extra strong or double extra strong stock is used in making the stronger grades, since the increase of metal thickness is always on the inside.

Outside Size Same for All Grades

Piping of all grades must necessarily have the same outside diameters to insure threads of uniform depth and fullness, for it is essential to good work in any kind of a piping job that common pipes be as well threaded as those of extra strength, regardless of the service to be supplied. If the pipe is not full size, the thread will be more or less scant, and it is well-nigh impossible to make a scant thread permanently tight. The outside diameter of any grade of 1-in. iron or steel pipe, for example, is listed in the tables of dimensions as 1.315 in. The metal in a well-made standard 1-in. pipe is 0.134 in. thick. The thickness of the corresponding size of extra strong pipe is 0.182 in., or a little over one and one-third times that of the ordinary pipe, while the thickness of double extra strong pipe of the same size is given in the table as 0.358 in., nearly twice the thickness of extra strong. It is not unusual to find common merchant pipe as much as one-third thinner than it ought to be to give good service under pressure. With good sharp dies a respectable looking thread may be cut on this light pipe, if the thinness results more from increasing the inside diameter than from diminishing the outside, but the metal may be so reduced that the threads can be counted on the inside of the pipe. When connected up in a steam system such pipes lack the rigidity in the threaded joints

that gives security against vibration or leakage with its inevitable corrosive effect.

No pipe should be used in a system designed to resist pressure unless it will stand up firmly under the grip of proper-sized wrenches or tongs. Good standard pipe will fulfill this requirement, but the general output of merchant pipe will not. For oiling systems under low pressure and for waste pipes, drips and gas lines, and for all relatively unimportant service about the plant, merchant pipe will do. It should not be used in water or steam lines under any pressure. For bent work it is utterly unsuited, as it will almost invariably open up at the weld.

It is the custom, arbitrarily assumed perhaps, to mention the outside diameter in listing all pipe having a nominal inside diameter greater than 12 in. Thus, a pipe that measures approximately 14 in. inside is designated as 15-in., since this represents its actual outside diameter.

It is often noticed that heavily galvanized standard pipe cannot be threaded with ordinary hand dies unless a short taper is first filed on the end of the piece to be threaded. If the plain black pipe is of ample weight, the coating of zinc applied in the galvanizing process will enlarge it just enough to keep the die from taking hold. When cutting galvanized pipe, care should be taken to see that the lengths are unobstructed inside from end to end, since it not infrequently happens in galvanizing that the zinc chills and gathers on the inside surface in beads, thus diminishing the effective area of cross-section more or less. A good way to find out if this condition exists in piping of small size is to roll a marble through. To be an effective gage in this respect, the marble should of course be but slightly smaller than the bore of the pipe.

The character of the weld is vital to the security of wrought-iron and steel pipe. Pipes of all sizes up to and including 1¼-in. are butt-welded. In pipes above this size the welds are lapped. In good pipe the weld is almost invisible to ordinary scrutiny. Imperfectly welded pipe is dangerous in service and is troublesome to cut and thread. Full standard-weight pipe that is perfectly welded and cleanly threaded will have sufficient margin of strength to satisfy every requirement of safety in steam service under prevailing pressures. As a matter of fact, we may feel secure in using such pipe in sizes up to 1-in. in hydraulic work calling for pressures up to 1000 lb. Where the pressure exceeds this figure or the size of the pipe required is above 1-in., safety demands extra and double extra strong pipe.

Compound Ammonia Compression*

By H. J. MACINTIRE
Assistant Professor Mechanical Engineering, University of Washington

Compound ammonia compression is helpful when using extreme suction and condenser pressures. The advantages should be great enough to overbalance the extra first cost, depreciation and operating expenses of the second unit.

CONSIDERABLE interest is at present taken in devices for securing compound ammonia compression. Its application to air compression is old, but although frequently advocated, compounding has not been used in America except for most unusual cases —such as for sharp freezers which require a low suction pressure. The author desires to bring out in the following as clearly as is possible the advantages and limitations of stage compression for ammonia and the theoretical advantages of such operation.

To begin with, there is no advantage in using a second cylinder for compression if the range of pressures is not great. In air or ammonia compression, when the cylinders are water-jacketed, the compression curve approximates the adiabatic, which is much steeper than the isothermal (constant temperature) process. The result of having to use this compression curve is that more work has to be done in the cylinder to arrive at the desired pressure, and in consequence a much higher discharge temperature from the cylinder is encountered. Neither of these conditions, extra work of compression or higher temperature of the ammonia, is of such importance except when the range of pressure is great. Even in the case of 10 lb. absolute suction and 185 lb. gage condenser pressure, as seen in Fig. 1, the saving is 13.2 per cent. Is this sufficient for the extra first cost and maintenance?

Fig. 2 is called the heat diagram, because it shows the change of heat contained in a unit weight of the ammonia, and the inclosed figure shows the difference between the heat removed by the cooling water in the condenser and that supplied by the refrigerating coils

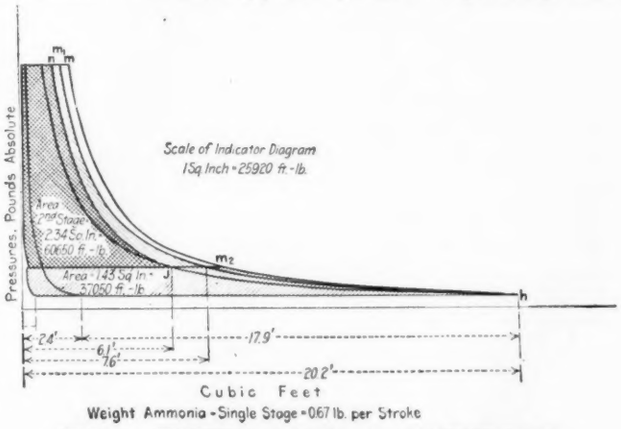


FIG. 1. SHOWING SAVING OF COMPOUNDING

(that is, the amount added to the refrigerant by the compressor) to be able to continue its use. A vertical line on the diagram[1] represents an adiabatic compression or expansion; that is, one during which no heat is

*For other discussion on this subject see "Power," Aug. 15, 1916.

[1]As a matter of fact the flow through the expansion valve is not perpendicular (adiabatic), but as given by the curved line (constant total heat or a throttling effect), in consequence of which more vaporization occurs than should; that is, $\frac{eg}{eh} = \frac{29}{144} = 20.1$ per cent. instead of 18.1 per cent.

added or taken away. For instance, if compression was adiabatic from the 10-lb. to the 200-lb. condition, it would be represented by the line hm, but the jacket takes some heat away, and the real compression is hm_1. The temperature corresponding to the point m is 280 deg., while that of m_1 is 240 deg., whereas when using compound compression, indicated by the line hm_2, the temperature is 195 deg. Lately, considerable notice has been taken of the effect of high discharge temperature on the chemical stability of ammonia, so that for this reason it is desirable to keep the discharge temperature as low as is possible.

Another consideration is in regard to the condenser. One of the greatest improvements in ammonia condensers has been in making it flooded; that is, in bringing the superheated ammonia from the compressor in intimate contact with surfaces wet with liquid ammonia, thus directly increasing the coefficient of heat transmission of the condenser. So, from the standpoint of the condenser it is desirable to have as low a degree of superheat in the discharge from the compressor as is possible.

Inter-Cooling a Problem

In air compression the temperature range in the compressor is well above that of the surrounding air. Such being the case, the work of providing a ready means of cooling the compressed air in the intercooler and the aftercooler is simple. With ammonia (or in fact, any refrigerant) the problem is, however, a real one. In the diagram the temperature of saturation at 35 lb. abs. is 6 deg. F., and we should require a discharge pressure of 47 lb. gage (62 lb. abs.) before we could get a temperature of saturation of 32 deg. F. With this preamble it is easy to see that if a practical intercooler is to be provided, the cooling medium must be liquid ammonia maintained at the pressure of the discharge from the first-stage compressor.

In large plants, using more than one suction pressure —as for example, in the case of ice making or moderate temperature cold-storage rooms and sharp freezers —the problem is comparatively simple, and an arrangement similar to the precooler or congealing tanks in ice plants may be employed, using the wet vapor from the higher-pressure stage as the cooling medium. Where one boiling temperature of ammonia only is used, more care in operation will be required, as two expansion valves will have to be employed—one to lower the pressure to that of the intercooler and the other to regulate the pressure of the cooling coils. This arrangement is best explained in the Aug. 15, 1916, issue of *Power*, which gives also a special design of intercooler on the principle of the flooded condenser.

Heat of the Liquid a Loss

One of the inherent losses of the refrigerating cycle is that due to the heat of the liquid. This is an absolute loss, and theory does not give in this respect any prospect of relief. The difficulty is that the liquid ammonia is cooled as low as is possible in the condenser, say to 60 or 70 deg. F., but before any useful refrigeration may be done the ammonia itself must be cooled to the temperature corresponding to its boiling pressure. In other words, before it will take heat from the brine to be cooled or the air in the cold-storage plant, it must make itself cold. Thermodynamics does not give any hope of relief from this loss, and in fact the net loss is considerably greater than is at first apparent. For example, the line qg_1 is generally used to represent the process through the expansion valve, and the ratio of the lines $\frac{eg_1}{eh} = \frac{24}{144} = 18.1$ per cent. shows the decimal amount (of a unit weight passing the expansion valve) which, by absorbing the "heat of the liquid" and thereby becoming vaporized, is useless for practical refrigeration. A number of the "gravity-feed" systems are of value mainly because this vapor is separated from the liquid before allowing the refrigerant to pass to the cooling coils, thus increasing the efficiency of the expansion coils by decreasing their choking in consequence of being gas-bound.

In compound compression the liquid is cooled in two stages and $\frac{ab}{aj} = \frac{15.4}{121.5} = 12.7$ per cent. and $\frac{ef}{he} = \frac{13}{144} = 9.04$ per cent. are vaporized each time. The advantage, however, is that although nearly the same amount of

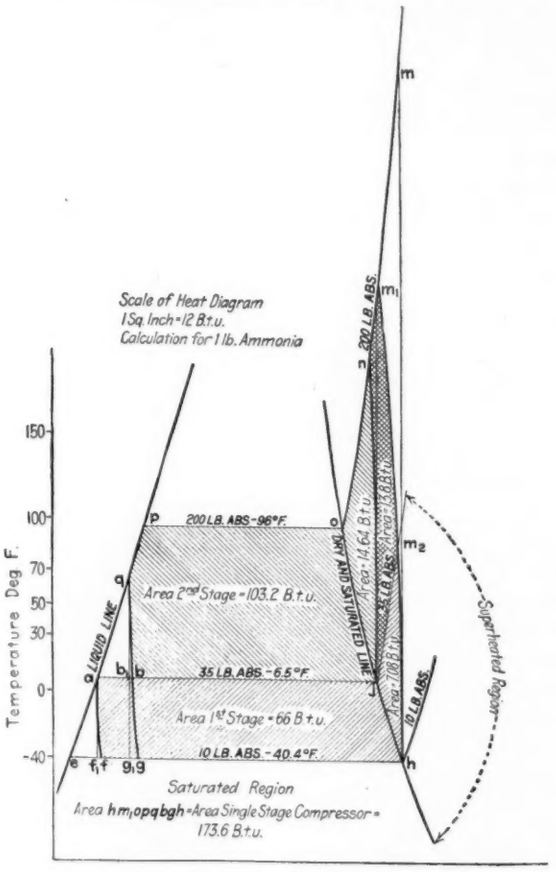


FIG. 2. HEAT DIAGRAM, COMPOUND AMMONIA COMPRESSION

vaporization occurs in the two stages as in the single-stage pressure drop through the expansion valve, yet the specific volume at 35 lb. is but $\frac{7.93}{25.75} = 30.8$ per cent. of the amount at 10 lb. The 12.7 per cent. vaporized at 35 lb. is compressed in the high-pressure cylinder only, thereby saving 5.14 per cent. of the amount of work required of the compressor and increasing the possible tonnage of the machine in proportion.[2]

[2]The tonnage is determined by the piston displacement of the pressure piston.

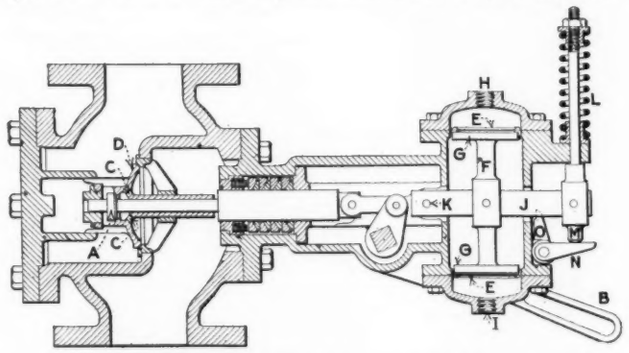
The clearance volume has been given considerable attention by designers and writers, but tests under moderate operating pressures have indicated but slight increase in the horsepower per ton of refrigeration. With leaky valves or too heavy feed of the liquid under wet compression, and especially with low suction pressures, the loss of volumetric efficiency becomes excessive. For example, in Fig. 1, a clearance of 1 per cent. was assumed, which gave an efficiency of $\frac{19.2}{20.2} = 95$ per cent. at 35 lb., and $\frac{17.9}{20.2} = 88.6$ per cent. at 10 lb. for single compression. The gain by using the compound cycle is shown as 10.3 per cent. inasmuch as in the theoretical case the low-pressure cylinder would have a clearance much less than the 5 per cent. previously shown, and the pressure range being small, the volumetric efficiency would be much greater than 88.6 per cent. In Fig. 1 this is shown at the extreme left.

Compound ammonia compression is advantageous when using extreme suction and condenser pressures. Its claim for advantage is in reduced discharge temperature in less compression work (9.0 per cent. in the conditions mentioned, allowing for that ammonia vaporized in the upper pressure stage due to the heat of the liquid, and the amount vaporized to provide for the cooling effect of the intercooler). The tonnage is increased 10.3 per cent. by reduced reëxpansion in the clearance volume.

The disadvantages are in having the extra first cost, depreciation and operating expenses of a second unit, and a much more complicated system. The saving may be nil unless careful attention to detail is enforced.

R-K Triple-Duty Engine Stop

In the R-K triple-duty automatic engine stop valve, the design is such that steam is not only automatically shut off from the engine in case of the rupture of the steam cylinder, piping, etc., but it is also electrically operated from a distance, and combined with these two features it can be operated manually as a shutoff-valve. This valve is shown in the illustration, together with several new features that have been incorporated in its design. As now constructed, steam enters the valve at the upper opening. A pilot valve *A* is for bypassing the steam, and the first upward movement on the lever *B* opens the pilot valve and admits steam through the ports *C*, and thus restores the pressure between the valve and the engine throttle, after which the disk *D* is opened.



DETAILS OF THE VALVE AND CUTOFF MECHANISM

The differential trip head is made with opposing pressure chambers sealed by metallic diaphragms with a central post *F*, having pressure caps *G* in contact with the atmospheric side of the diaphragms *E*. A connection is made at *H* with the steam header and at *I* with the engine supply pipe above the throttle valve. The lever *J* is pivoted at *K*, but can move up and down at the other end when actuated by the relative movement of the diaphragm. The tension on the spring *L* is to counteract the natural drop in pressure between the engine and the main header.

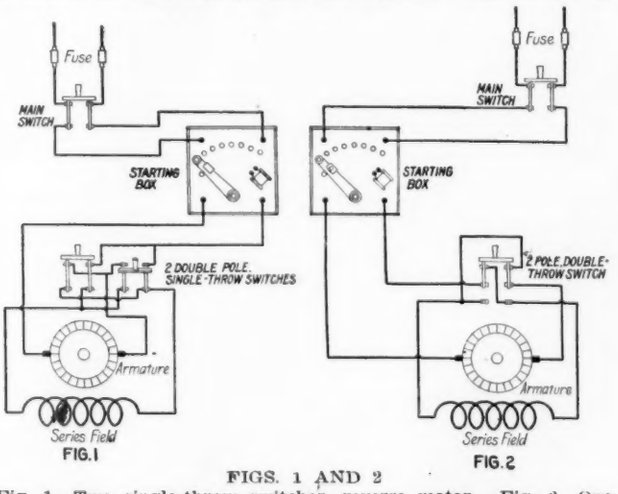
Should there be a sudden drop in pressure at the engine, the pressure on the lower diaphragm *E* will be reduced and the pressure from the steam header will force the upper diaphragm down, which brings the tappet end in engagement with the arm *N* and semi-rotates the trip shaft to disengage the pawl *O*, which releases a latch that holds the valve open and allows it to close by the steam on the under side of main valve disk.

The same result is obtained when a magnet that also actuates the pawl *O* is energized by the speed-limit governor, making contact on an overspeed or by the closing of the circuit from any of the station boxes. As soon as the circuit is closed, the armature is attracted, which will cause the trip shaft to rotate until the latch is released, thus permitting the main valve disk to close, as when released by the action of the diaphragm.

This engine stop is manufactured by Walter G. Ruggles Co., 54 High Street, Boston, Mass.

Reversing a Series Wound Motor

Connecting up a series wound motor so that it can be reversed may be done in either of two ways. Fig. 1 shows a method using two double-pole single-throw switches. To run in one direction the left-hand switch is closed and the right-hand one opened. The motor is then started in the usual manner by moving the handle of the starting rheostat over the contacts. To reverse the motor, open the left-hand switch and close the right-hand one and start as before. Another way is shown in Fig. 2, in which a double-pole double-throw switch is used in place of two single-throw switches. The latter method is safer for the reason that there is no possibility of having both switches closed at the same time to cause a short-circuit, which would blow the fuses.



FIGS. 1 AND 2

Fig. 1—Two single-throw switches reverse motor. Fig. 2—One double-throw switch does same, reversing a series motor

A Variety of Indicating Devices

FIG. 1. TEMPERATURE INDICATOR
Rising temperature causes the fluid in the bulb and tube to expand, tending to straighten the indicator coil

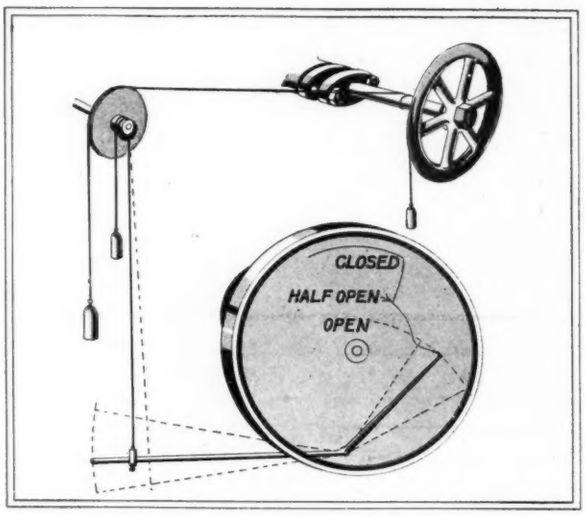


FIG. 2. VALVE INDICATOR
Shows the position of a valve, wide open, partly open, or shut, and a clock records the time of changes

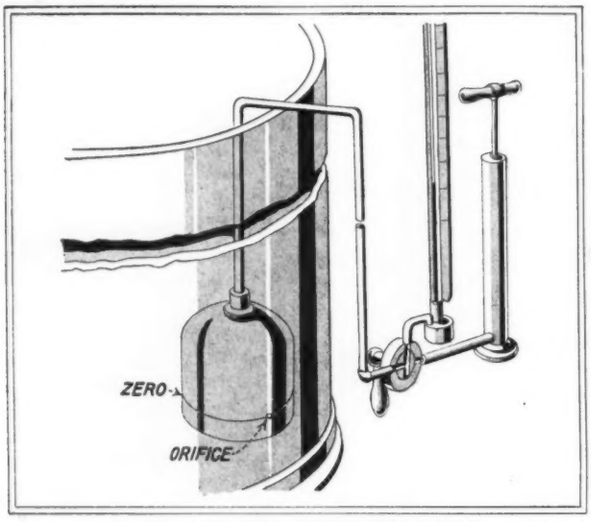


FIG. 3. THE PNEUMERCATOR
Depth of liquid or submergence of a vessel is shown by air pressure on the graduated gage

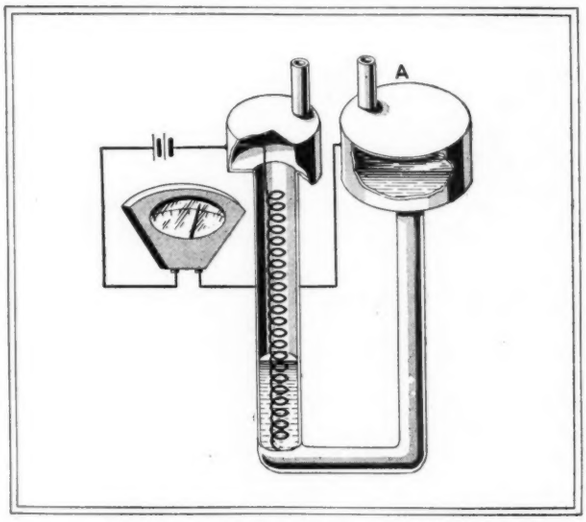


FIG. 4. LIQUID-LEVEL INDICATOR
Increased pressure at A raises the mercury level, changing the resistance, which is indicated by the graduated meter

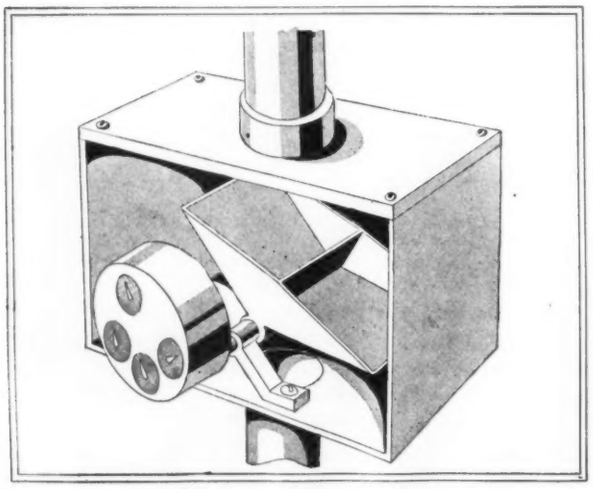


FIG. 5. LIQUID METER
The quantity required to fill the bucket and tilt it over is predetermined and each emptying is registered

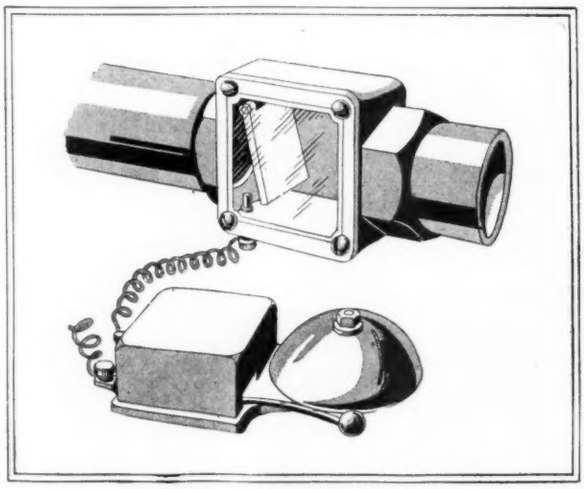


FIG. 6. FLOW INDICATOR
When there is no flow, the flap makes electric contact with the insulated pin, thus ringing the bell

Editorials

The Lost Opportunity

WHEN a leading coal operator from the Middle West, testifying as a witness on the bituminous-coal situation before the Senate Committee on Interstate Commerce, tried to justify the present prices of coal by pointing out that the operators in the Middle West fields during the last fifteen years have made an average profit of only one per cent. on their investment and that, being human, they would take advantage of an opportunity, he showed that the coal operators have failed to recognize the handwriting on the wall. Whatever may have been the cause of the bituminous-coal operators not earning a reasonable profit, to take advantage of an emergency such as the present crisis is unjustifiable. Furthermore, it would seem that thev have failed to make use of their opportunity to earn a reasonable profit and at the same time gain the confidence of the public.

Taking the estimated production of bituminous coal for 1917 as six hundred million tons and the capital investment as one and a half billions, which is probably considerably in excess of the actual capital invested in the bituminous-coal industry, an increase of fourteen cents per ton over and above the higher cost of production would have paid an additional five and six-tenths per cent. on this investment. It is doubtful if there would have been any objections raised to an increase of twenty-five or fifty cents per ton, and this would have paid more than a reasonable profit, yet in some cases coal prices have been raised three and four dollars per ton.

When this witness was pressed for an opinion as to what profit he thought the operator should be allowed, he set the figure at one dollar per ton. This would be equivalent to a forty per cent. dividend on a one and a half billion dollar investment. When Senator Pomerene called attention to the fact that such a profit would mean a tax of six dollars per year to every man, woman and child in the United States, the witness replied that if in his own business he could contract for all his output for the next ten years, he would be willing to do it at a profit of twenty-five cents per ton. At the present rate of production this would mean a guaranteed profit of one hundred and fifty million dollars per year, or ten per cent. on the estimated investment, and would seem to be a reasonable profit even in war time, let alone a guarantee for ten years.

The coal operators have already promised to reduce their prices, but whatever may come out of this reduction, the fact remains that they agreed to compromise only after the Government had threatened to take over the control of the mines.

Summing up the facts as they have presented themselves in the coal situation, it appears that the coal operators have been deluding themselves with the same idea that many public-utility companies harbored in the past; namely, that public necessities belonged to the few that might be fortunate enough to get control of them, to be run for their own aggrandizement, and that the public had to take what they could get at a price the operators saw fit to dictate. However, most of these utilities have found out that the public has considerable to say about both price and quality of service.

Secretary Lane, in addressing the coal operators, said: "A public utility is one that is at the service of anyone and must render him the kind of service it holds out to give. In the biggest and broadest sense each one of you in running a coal mine is managing a public utility, because the public is dependent upon you." This is the very point that the coal operators fail to grasp, and they lost their opportunity to show the public that their patriotism was measured in something more than extortionate profits; that they put the country's interest in the present crisis above their own aggrandizement; and that they were too big and broad to take an unfair advantage of a national emergency, and thereby to show themselves worthy to be trusted with the administering of a public necessity.

The New Station at Albany

ELSEWHERE in this issue appears a description of the new steam station of the Municipal Gas Company, Albany, New York. It is a small station as stations go nowadays, but it is not its size that is interesting. It is the station's simplicity of design, its arrangement of equipment and its low cost—for it must be low though it is anything but cheap—that make it one worth giving space to in our columns. And this is all the more interesting when it is known that it was originally intended as a stand-by station for the water power at Speir Falls and Cohoes that supplies Albany, Troy, Cohoes and vicinity.

The Hudson River, on which the station is situated, rises many feet during flood periods. The manner of waterproofing the station against these floods, described and illustrated in the article, will be welcomed by the reader. Engineers particularly will be interested to note that a variable-speed drive for the stokers is used, the stoker engines running at constant speed. This is the fifth station designed by Thomas Murray to use this type of drive; and so far as we know there is but one other station using them; namely, the Essex Station of the Public Service Electric Co., Newark, N. J., described in *Power*, Nov. 28, 1916. Other than these engines, nearly all auxiliaries are turbine-driven.

Other features of interest are the steel stacks which, though nine and a half feet in diameter, are unlined. The new Dayton, Ohio, station, designed by Mr. Murray, has unlined steel stacks. It is likely that there will be some interesting discussion as to when and when not to line steel stacks. *Power* welcomes such discussion.

The readers' attention is called to the table of important data with its ratios relative to the station, which the author has incorporated in his article. The value of such tables to the student, the operator and the designer is obvious. The 7500-kilowatt turbines have condensers with but 8000 square feet of tube surface, giving a ratio of tube surface to rated kilowatt capacity of a bit less than 1.07. When bearing in mind that the condenser is small and that therefore large "dead" areas are not present, the amount of tube surface is indeed low, making an unusually high heat transmission rate necessary.

The simplicity of this station and that of others recently built indicates that the days of the bronze-door. marble-lobby station are gone. And why not?

Boost—Don't Kick!

IN TIMES of stress like these, we are all prone to criticize and find fault with the apparently slow movements on the part of Government officials and those in charge of our war work, without due consideration of the magnitude of the task and the seriousness of a comparatively small error. In lesser enterprises it is understood that plans must be matured, drawings and specifications prepared, material assembled and a force of operatives assembled and trained before any extensive operations can be carried out or even got under way. If those disposed to find fault would first acquaint themselves with that which has already been done, as made public, and could learn of the multitudinous details that cannot, from their nature, be made public, it is quite likely that criticism would give way to praise.

A single instance that will serve as an illustration is that of the several contingents of expert foresters already sent overseas and hard at work. These men were fitted out on this side with all the implements of woodcraft from complete steam sawmills to camp kitchens, so that they are prepared to "take to the woods" and remain there indefinitely, dependent only on a food supply of the most primitive kind. The surprise and admiration excited by their arrival so promptly and completely equipped is all the more striking when it is considered that almost three years' experience has been accumulated in these countries in organization and preparation.

Let all abstain from harmful criticism and if necessary be lenient. It is obvious that the workmen of one class—machinists, for example—cannot begin their work before the architect and builder have developed and carried out their part of the work on the new factory building. This is an entirely new factory or plant that "Uncle Sam" is building, and all the machinery cannot be built and the employees organized overnight. Boost, but don't kick!

War a Matter of Mechanics and Engineering

WHEN a people are facing a great national problem like the present, it is always gratifying to hear the opinion of the nation's leaders, whether they be industrial, political or military. Readers of *Power* will appreciate reading the address published elsewhere in this issue, of one of our prominent industrial leaders, E. W. Rice, Jr., president of the General Electric Company and of the American Institute of Electrical Engineers, on "War a Matter of Mechanics and Engineering."

This address expresses the sober, deliberate and well-balanced thought of a captain of industry and engineer, the expression of one who by long years of experience has become accustomed to doing big things and knows that there is only one way that they can be done, especially a momentous task like bringing the present war to a successful and honorable termination—by devotion to a cause and by hard work, or, as Mr. Rice has expressed it: "War calls for supreme sacrifices and the deepest devotion, but it also demands something more difficult to give, and that is *work*. War may be said to be the personification of work—not only individual work, but especially organized and disciplined work—disagreeable, dirty, heart-breaking, back-breaking, nerve-racking work. No nation of loafers ever won a war. Other things being at all equal, that nation or people who are willing to work the hardest will surely win the victory."

A recent editorial commenting on some tests of refractory furnace materials called attention to a statement that magnesia, when subjected to low temperatures, disintegrates in time. The statement appears to have been susceptible to misunderstanding among some readers as to what was meant by "low temperatures," the term being intended in a relative sense only. We were talking of furnace temperatures, which, even when relatively low, are much in excess of steam-pipe temperatures. In fact, the curves plotted from the tests did not show any loss in insulating properties at the latter temperatures. In view of this the abstract of Dr. Mattison's paper elsewhere in this issue is opportune and should tend to clear up any misconception arising through the omission of a more explicit statement.

The wonder is not that a democracy makes mistakes, but that it gets on as well as it does. This is again borne out by a rider in the food control bill. This rider aims to prohibit "any person connected with the Government" from selling to the Government anything in which he has a financial or business interest. Obviously, unless eliminated from the bill, this spells the collapse of the Council of National Defense, which is made up of some of America's greatest business men and engineers. This rider is impudent. It has no place in the food bill. It is the sort of thing that provokes the disgust of intelligent citizens because it blocks the wheels of progress at a time when action, not words, mean the very preservation of national welfare.

Correspondence

Corrosion About the Power Plant

The article by Prof. H. J. Macintire on "Corrosion About the Power Plant" is open to criticism on the score of a rather vague and unbalanced presentation of the electrolytic theory of corrosion, with the result that the uninitiated is likely to get a distorted opinion of the various factors involved and their relative importance. The mechanism of self-corrosion, electrolysis and corrosion by stray currents involves the same factors qualitatively. Variations in observed effects are due essentially to variations in intensity of the several factors, whereby corrosion may proceed in the one case and not in the other. The article appears in the June 5 issue.

In the article undue emphasis is placed upon mill scale, contact with cinders and the like, to the neglect of the more important accelerating or retarding influences due to service conditions and to composition or physical characteristics of the pipe metal itself.

Mill scale is slightly electronegative to iron or steel, and therefore tends to accelerate corrosion provided there is exposure of bare iron or steel in an area immediately adjoining and in contact with the scale. However, mill scale is in itself one of the best protective coatings we have, and the protective influence greatly outweighs the counter effect of acceleration, so that, given the choice between ordinary black pipe and pipe from which the black finish or mill scale has been removed, one would be better off with the former.

Oxide Formed When Welding Pipe

To speak of segregation of the mill scale and of "scale evenly distributed, as in spellerized steel," is entirely misleading. Segregation is the result of selective separation during solidification of molten material; mill scale is the result of heat oxidation of the *surface* of the pipe. During the time the pipe is exposed to the welding temperatures, this scale forms in fairly uniform thickness over the whole surface. Spellerized pipe is no more free than any other kind, since spellerizing is a mechanical operation on the metal while in ingot form at the very beginning of pipe manufacture. And spellerized material, similar to nonspellerized, goes through the same number and character of heating and working operations to form the finished pipe.

There is no question of the increased rapidity of corrosion once it has started, for rust, once formed, is a powerful accelerator of corrosion and pitting. In other words, rust breeds rust and is a relatively far more important factor in the progress of corrosion than the presence or absence of mill scale. But of much greater importance than either of these factors are the conditions of service, for every engineer knows that pipe will stand up for years in certain service, while the same pipe under different conditions may rust out and have to be replaced at relatively brief intervals of time. The need of protective barriers within the metal to resist or retard the corrosive attacks, therefore, must be emphasized. Cast iron and wrought iron possess this characteristic in their graphite and slag respectively. In addition, surface coatings of varying characteristics may be applied—the most common of which is galvanizing.

To say that zinc should be avoided in steel pipe lines or in brine lines is going contrary to best practice. Galvanized coatings are in general the best to be had, because of the mechanical protective effect of the coating itself and the electrolytic protective influence on the contiguous iron or steel, once the coating is punctured.

This protection of an electrolytic nature results in solution of the zinc. The zinc does not protect itself at the expense of the iron; as a matter of fact, the tables are reversed. Zinc, being electropositive to iron and steel, tends to spread out and cover up abraded spots, protecting the bare base metal from attack as long as there is any zinc left. In ordinary service a galvanized pipe can be no worse than a black pipe, and in most cases it has a materially greater life. Furthermore, the galvanic influence of the zinc extends over a very limited zone, being practically limited to the pipe itself, and under no conceivable circumstances could it be extended from the ice cans to surrounding tanks or expansion coils and even if it did the results would not be harmful but rather the reverse.

James Ashton.

Pittsburgh, Penn.

Testing Treated Boiler Water

Replying to George Smith, on page 780 in the issue of June 5, who asks for information on treating boiler-feed water, I would say that I find the soda-ash and lime treatment one of the best when handled right. Generally speaking, an open heater used in conjunction with the softening plant gives better results than a closed heater where the water contains an excessive amount of scale-forming matter. Whatever sediment passes the softening plant may be precipitated in the heater and removed periodically at small cost. We have the heater blown out "good" several times during a day's run and open and clean the heater frequently, and find that it does its part of the work and more. The closed heater is ideal for water free from scale-forming matter, but if there is much foreign substance, the passages soon become scaled up, the efficiency of the heater is lowered and it proves to be a bad investment.

Mr. Smith asks for a brief explanation of the lime soda pretreatment without a complicated analysis, but this is such an important matter in any power station one is justified in devoting, in fact has to devote, considerable time and patience to it. The only way one can expect to get good results is to get a correct analysis of that particular water to know what percentage of lime and soda ash to use. A sample of the water should then be tested every day to see if the right proportion of the solution is being used. After learning how to make an analysis, one is able to get excellent results.

Following are practical suggestions how to fit your apparatus up: You will need two 1-oz. vials, one for phenolphthalein and one for methylorange. To 1 oz. of alcohol add about as much phenolphthalein as will lie on the point of a small blade of a penknife (about ⅜ in. from end), place this in one bottle and label it "clear indicator." Put in the other bottle 1 oz. of distilled water and add as much methylorange as will lie on the point of the knife (too much makes it too rich in color) and shake well. Label this "color indicator." You will need two burettes—one for the standard acid solution and one for the soap solution. It is best to buy standard solutions or get some registered chemist to make the acid and soap solution up for you.

In testing for hardness, measure out 100 c.c. of treated water into a bottle and run in ½ to 1 c.c. of soap solution at a time from the burette and shake well after each addition of the soap solution; as soon as a permanent lather is formed, enough has been used. The number of cubic centimeters of soap solution used in obtaining the permanent lather is termed the percentage of hardness—each cubic centimeter of standard soap solution used in obtaining the permanent lather indicates one grain of hardness in the water. To determine the alaklinity and causticity, measure out 100 c.c. of the treated water into a bottle, add 2 drops of the red indicator and 3 drops of the clear indicator and from the standard acid burette from ½ to 1 c.c. of acid until the red color just changes to yellow. The number of cubic centimeters of acid solution used gives the percentage of causticity. Run in more of the standard acid solution until the yellow color just changes to pink. The total number of cubic centimeters of standard acid solution required to produce both color changes is termed the percentage of alkalinity.

Treated water should show tests about as follows: Hardness, 5; causticity, 4; alkalinity, 6. When too much lime is used in the treatment, the causticity in the purified water, as indicated by the acid test, will be nearly equal to the alkalinity; if too little lime is used, the causticity will fall to approximately half the alkalinity. The hardness should not be in more than two points less than the alkalinity. Where too much soda is used, the hardness is lowered and the alkalinity raised; if too little soda, the hardness is raised and the alkalinity lowered. It is necessary to have the treating plant arranged in the right manner for precipitating the scale-forming elements to get good results. Try blowing boilers down oftener to see if that does not reduce the priming.

C. R. REYNOLDS.

Oklahoma City, Okla.

Cooling Hot Boxes

I believe Mr. Hamkens (*Power*, May 1, page 600) is right concerning the danger of throwing water on an overheated crankpin or crosshead-pin bearing, notwithstanding A. K. Vradenburgh's criticism on page 839 of the June 19 issue, for it stands to reason that when the brasses are first heated they tend to expand at the bearing surface and to increase their bore, but are prevented from doing this by the strap or connecting-rod end.

If the brasses have heated quickly and to such an extent as to cause the inner or bearing surface to take a permanent set due to the resistance offered to their expansion by the outer portion of the brasses and the connecting-rod ends, it is evident that when suddenly cooled, that part cannot contract and will thus be caused to grip the pin, owing to the contraction of the outer portions. This explains why some bearings have a chronic tendency to heat. They have been overheated at some time, and the inner surface of the brasses has taken a permanent set and will grip the pin slightly until the remainder of the brasses and the rod ends are sufficiently heated to enable them to release the pin due to the expansion of the outer parts. This will be indicated by the bearing temperature remaining constant.

Del Monte, Calif. A. C. MCHUGH.

Electrical Service Discussion

Your editorial in the Apr. 17 issue referring to the meeting of the Boston sections of the A. S. M. E. and the A. I. E. E. at the Wentworth Institute, where they were to discuss the pros and cons of purchased or isolated plant power, also Morris Llewellyn Cook's letter about this meeting (May 8 issue), was of interest to me, and I have been looking for more letters on this subject from those who, like Mr. Cook and myself, dislike the methods of control of these societies. Not seeing any more, I am taking the liberty of sending in one

It is almost impossible to get a fair and open discusion of private-plant service as opposed to purchased power; and even a fair discussion of the central-station rates and their methods of business is out of the question. It is easy enough to get one side, but the other side must not be mentioned. Whenever purchased power is discussed, marked emphasis is placed on the fixed cost of the private plant, and many charges are added that were unthought of until it was found that without these being included, the central station could not make out a favorable case. A fair-minded study of the rates of the central stations will disclose that the rates they quote to obtain the business of the private plant could not be given if their other customers were also allowed a fair rate.

In making out the case for the central station, we find that the private plant is loaded with fixed costs, composed of taxes, interest, depreciation, obsolescence, maintenance, profit ratio, insurance against fire, insurance against loss in operation, etc.—these charges often being a very large proportion of the total operating cost and always from 25 to 30 per cent. of the plant capital cost. In addition the labor costs are often charged to power, notwithstanding that this labor may be used for other purposes about the plant, while the heating value of the exhaust steam is either entirely neglected or its value minimized. If, however, we look over the reports of the central station, we are unable to find many of these charges in their costs.

Here, for instance, is the report of the Edison Electric Illuminating Co., of Boston, for the year ended June 30, 1916. It will be noticed that the total assets are $48,844,-692.34, and that the total active assets, subject to depreciation and maintenance charges, etc., are approximately $44,000,000. In the manufacturing account we find that the total manufacturing costs are $4,650,-615.26. The only charge in the manufacturing account that can be called fixed is the taxes. On the profit-and-

loss account we find interest paid, $297,248.46; reserve fund, $600,000; dividends declared, $2,702,184. These are the total fixed costs that we can find in this account, and the reserve fund can only by courtesy be called a fixed charge, for we do not know for what it was reserved. These figures amount to $4,554,192.70, or 9.34 per cent. of the total capital cost of the company. If we assume that the reserve fund of $600,000 is for depreciation, note that it is but 1.23 per cent. of the active assets. Compare this figure as well as the total fixed costs with similar charges that the central stations wish to make against the private plants. In the report one finds nothing in the way of depreciation, obsolescence, insurance or the many other charges they wish placed on a private plant. Why?

EDISON ELECTRIC ILLUMINATING CO. OF BOSTON

Assets

Electric plant:	
Lands	$2,994,495.89
Buildings	6,461,638.33
Steam plant	5,535,876.75
Electric plant	6,926,319.38
Overhead lines	6,436,912.76
Underground conduits	4,718,529.86
Underground wires and cables	8,365,197.76
Transofrmers	824,374.93
Meters	1,535,707.86
Street lamps and fixtures	401,508.69
	$44,200,562.21
Other assets:	
Properties purchased	$669,242.52
Permanent investments	1,304,840.12
Cash	489,388.00
Notes receivable	2,376.24
Due for electricity	737,276.29
Sundry accounts due the company	112,596.49
Electric fuel on hand	127,079.40
Motors on hand	1,186.33
Other electric materials and supplies on hand	777,441.50
Stable and garage equipment	401,684.91
Sinking fund	21,018.33
	$4,644,130.13
Total assets as per books of the company	$48,844,692.34

Liabilities

Capital stock, common	$22,518,200.00
Bonds issued	1,405,000.00
Coupon notes	28,500.00
Other notes payable	4,980,000.00
Unpaid bills	166,633.90
Deposits by customers	64,191.30
Unpaid dividends	675,546.00
Interest accrued but not due	81,858.93
Premium realized on stock issues	17,906,896.61
Reserves	862,853.49
Total liabilities as per books of the company	$48,689,680.23
Profit and loss balance	155,012.11
Total credits	$48,844,692.34

Manufacturing Account

Operating expenses:		Dr.	Cr.
At station	$1,464,079.99		
For current bought	74.77		
Distribution	967,886.49		
Management	1,048,684.93		
Taxes	954,760.24		
Incidentals	215,128.84		
		$4,650,615.26	
Income from sale of electricity,			$8,302,814.55
Other sources			26,021.52
Balance to profit and loss		$3,678,220.81	
		$8,328,836.07	$8,328,836.07

Profit and Loss Account

	Dr.	Cr.
Balance June 30, 1915		$127,275.08
Balance of manufacturing account		3,678,220.81
Interest received		21,013.56
Jobbing		22,938.86
Other items of income		81,015.36
Interest paid	$297,248.46	
Dividends declared	2,702,184.00	
License payments	75,000.00	
Properties purchased	100,000.00	
Reserve fund	600,000.00	
Other items	1,019.10	
Balance June 30, 1916	155,012.11	
	$3,930,463.67	$3,930,463.67

At a recent hearing, the lawyer for this company stated that the company did not figure depreciation, but that it carried the plant on its books at full cost value until it was sold, and that it was then marked off the books. Thus the company carries on its books the plant of the old Boston Electric Light Co. at L Street at full cost value, regardless of the fact that it could not be sold today at more than scrap value. In this plant there is 9000-kw. apparatus which cost about $125 per kilowatt, or a total cost of $1,125,000 on which the customers are paying charges. This apparatus is practically worthless, but the owners claim to carry it as a reserve plant, although they have in addition to this about 30,000 kw. in reserve in turbines. This probably is not all, as there are unquestionably many other pieces of apparatus that are being carried in the same way.

These are the people who ask for fair play in the hearings before the commission and who put a stop to fair discussion. This, however, is by no means all. This same type of people control the ethical matters of the societies.

Let us look at this matter in the light of our experience with corporations. Has history not shown that corporations have done with impunity many things which individuals dare not?

If there is danger that an individual may make changes in plans or what not for his individual gain, is there not more danger that a corporation will do so? An individual may be jailed, but you cannot put a corporation in jail.

HENRY D. JACKSON,
Boston, Mass. Consulting Engineer.

[It is not within our field to discuss corporations. We hold a brief for no particular one, and here refer only to the last two paragraphs of Mr. Jackson's letter. Modern business may be better carried on by corporations than by individuals, especially business that is in the nature of broad public service. There was a time when this was not so, and for some businesses it is not yet so. But with proper government supervision and regulation, the broad requirements of political economy and public service may be made to be best served by corporations.—Editor.]

Valve-Motion Discussion

There are some points in connection with the matter discussed in the article by H. F. Gauss, in the issue of May 29, page 740, that might not be clear to engineers using different types of engines from those indicated. For example:

If we have an engine crank *AO* and an eccentric *OB*, Fig. 1, it is obvious that a simple direct valve must be used, which is moved from its mid-position a distance equal to the advance of the eccentric from *F* to *B*, or an amount *Og*, this distance being the sum of the lap and the lead, and the engine runs in the direction of the arrow as the valve continues to open for this direction of rotation. Using an indirect valve, the eccentric is at *H*, and the movement of the valve is opposite for the steam to be admitted behind the piston. Therefore if a direct valve is used, the eccentric points away from the crank as *OB*, and if an indirect valve, it points toward the crank *OH*, the one being equivalent to the other, and gives the same direction of rotation.

There is some confusion in current literature regarding the use of the term "direct valve" as involving the admission of steam relative to the valve instead of relative to the eccentric location or valve-gear action. We may have a direct valve in either of two ways: An outside admission valve, as a simple D-valve, with no

reversal of motion by a rocker, or by means of an inside admission valve, as a simple piston valve, but with its motion reversed by a rocker. Conversely, we have two kinds of indirect valves: An inside admission valve without a rocker, or an outside admission valve reversed by a rocker. A direct valve is therefore one whose eccentric center moves along the center line of the engine in the same direction as the piston at the beginning of the stroke, while the ecentric for an indirect valve moves oppositely, being different by 180 deg. This definition makes the analysis of different valves consistent.

In the definition of open and crossed rods, they are termed either open or closed as they appear when the eccentrics both point toward the link and the crank is near the dead-center; and incidentally, if the eccentrics both point from the crank, we have a direct valve and if toward the crank, an indirect valve. By "driving eccentric" is meant the one that gives the greater motion to the valve. In any case the rods will open and cross during each complete revolution, but the definition of the setting must be kept clearly in mind. An engine should be checked up before being taken down for repairs, and again on reassembling, or embarrassment will result in trying to operate the engine with open rods when it was designed for crossed rods.

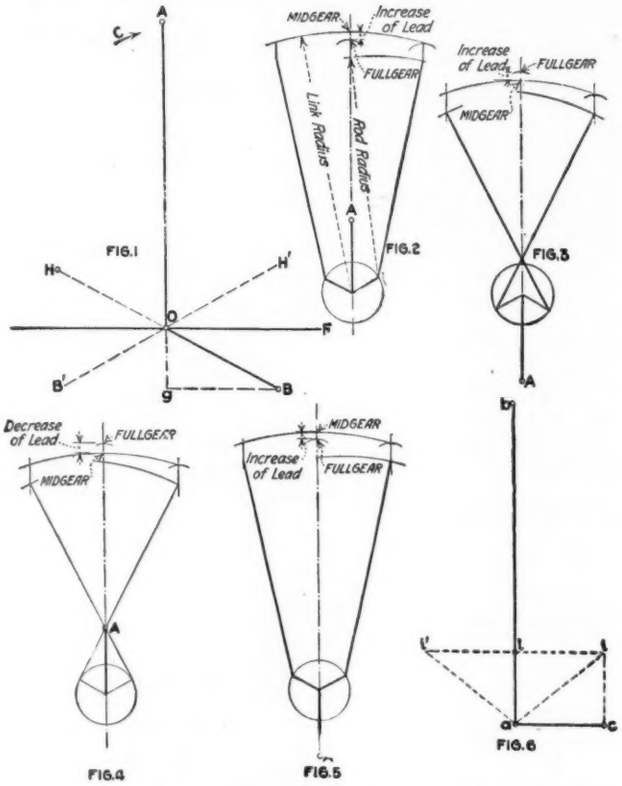
Illustrations Show Actions Graphically

The differences between these two connections may be seen from the following considerations and Figs. 2 to 5: In Fig. 2 the rods are termed "open" as the eccentrics point toward the link, and the lead is increased as the link is advanced to full gear, and an indirect valve is used. Fig. 3 is the same since the engine is on the other center, and the eccentrics point away from the link and the rods are crossed.

In Fig. 4 the eccentrics point toward the link, but the rods are crossed, therefore termed "crossed rods." The lead in this case is decreased. Fig. 5 is similar to Fig. 2, except that a direct valve is used. All engines that are reversed are set for equal leads in the full-gear positions; that is, with the link block in line with the eccentric rod, the engine of course being on dead-center. The amount of lead given depends on the size of the engine, its speed, type of valve and whether it is to have open or crossed rods. If the rods are open, the leads increase as the link (or reverse lever) is hooked up toward center. The lead (in mid-gear position) is the maximum port opening, and the valve returns from that point to make an early cutoff. This cutoff is early enough to secure economy, but can never be zero per cent. of the stroke. This is the condition desired and used in locomotive practice, since hooking up is done normally at the higher speeds. The increase of the leads is a distinct advantage of the Stephenson link motion, for it gives a wider port opening on short valve travels; otherwise there would be greater throttling and wire-drawing of the steam. When hooked up to mid-gear, the engine will take steam and, if not loaded too heavily, will continue to run in the same direction.

Traction engines are usually set with crossed rods, and the leads decrease as the gear is hooked up, usually to a negative value. In this case the valve will not open to steam nor will the engine continue to run unless the valve is leaky or has too small a negative lead for a proper seal. With crossed rods normally the cutoffs become zero before the mid-gear position is reached and vanish until the lever is well on the other side of center. If the lever is in mid-gear and the drains are open, there is no danger of the engine shifting until the position of the link lever is definitely shifted.

A two-crank cross-connected engine, such as a locomotive, must have its lever thrown well "down in the corner" in order to start with certainty in any position. If the load to be started is heavy, the large power of a long cutoff is necessary, but even with no load at all the cutoff must be nearly five-eighths of the head-end stroke, so that one cylinder will take steam if the other



FIGS. 1 TO 6. CHARACTERISTICS OF VALVE MOTIONS AND REVERSING GEARS

Fig 1—Diagram of a simple valve motion, direct and indirect. Figs. 2 and 3—How the Stephenson link produces an increase of lead moved toward full gear with open rods. Fig. 4—Conditions (opposite to Figs. 2 and 3) with crossed rods. Fig. 5—Similar to Fig. 2, except that it is for a direct valve. Fig. 6—Diagram of the Walschaert valve motion

is on or just before dead-center. These valve gears have the twofold function of reversing the engine and serving as expansion gears, thus enabling the engineer to hook up when less power is needed.

The Walschaert gear, if designed so that the driving eye of the link is in line with the link block in full gear, gives a combined motion that is nearly equivalent to the resultant of two eccentrics. As shown in Fig. 6, *ab* is the crank, *ac* is the actual eccentric, *al* is the crosshead or equivalent eccentric, and *ai* is the virtual eccentric for full gear in one direction and *ai'* in the other. In the case of a direct valve action, we have the radius rod connecting below the valve stem, thus giving an opposite motion, and the equivalent or crosshead eccentric is 180 deg. from the crank. For half-gear the virtual eccentric is located halfway between *i* and *l*.

West Lafayette, Ind. A. R. Nottingham.

The Training of Operating Engineers

I was interested in the editorial in the issue of June 12, concerning the better training of operating engineers. There is a woeful lack of appreciation of life's graver responsibilities on the part of our young people. There is, I believe, a feeling among educators even, that those trained along industrial lines must of necessity have little appreciation of art, music or literature, but that such should be the case is not at all necessary. It is entirely possible to train young men for operating engineering, to make them capable and efficient power-plant workers and at the same time give them a general education that will make them most desirable citizens and enable them to enjoy life in the broader sense of the word. The one requirement is that those charged with training these young men shall be sincere in their efforts and shall themselves have appreciation of the finer things of life.

There is hardly a community in America which may not, if it wishes, have a lyceum course in winter and a Chautauqua course in summer, at a cost that is not prohibitive. These institutions have been appropriately termed the "People's Cultural School." If the operating engineers of various communities would take interest in such movements, they would develop the traits mentioned in the editorial and have an excellent influence on the younger generation.

Trade Schools Should Carefully Direct

In trade schools taking up the training of the operating engineers the apprentice may be so guided that his interests will naturally develop along the lines of intensive technical work and his recreation in healthy sports and assembly periods where literature and music are presented for consideration.

Following is the outline of the course in operating engineering at Williamson Free School of Mechanical Trades, and it will be seen that the cultural side of the young men's training has not been forgotten. There is no reason why an operating engineer should be lacking in culture any more than the lawyer or physician. Notice how easily cultural subjects are introduced, without detracting from the technical work.

The academic course with the time in hours per week spent in the different departments, is as follows:

First Year, Apr. 1 to Aug. 1: Arithmetic, 3; Geography—General Review, 2; U. S. History—General Review, 2; Physiology—General Review, 2; Grammar, 2; American Literature, 2; Vocal Music, 1; Mechanical Drawing, 6; in shop, 20. Sept. 1 to Apr. 1: Arithmetic, 3; Algebra, 2; Physics, 2; Civil Government—General Review, 2; Grammar, 2; American Literature, 2; Vocal Music, 1; Mechanical Drawing, 6; in shop, 20.

Second Year, Apr. 1 to Aug. 1: Arithmetic—Mensuration, 3; Algebra, 2; Grammar, 2; Physics, 2; Chemistry, 2; English Literature, 2; Vocal Music, 1; Mechanical Drawing, 6; in shop, 20. Sept. 1 to Apr. 1: Algebra, 3; Geometry, 2; Grammar, 2; Physics, 2; Chemistry, 2; English Literature, 2; Vocal Music, 1; Mechanical Drawing, 6; in shop, 20.

Third Year, Apr. 1 to Aug. 1: Geometry, 3; Trigonometry, 3; Physics, 3; Chemistry, 2; Commercial Course, 1; Mechanical Drawing, 8; in shop, 23. Sept. 1 to Apr. 1; In shop, hours per week, 43. Evening Recitations: Strength of Materials, hours per week, 1½; Steam, Gas and Electricity, 1½.

One difficulty is that operating engineers themselves have not in all cases appreciated and risen to the high standard which their calling permits them to attain or developed themselves to the greatest possible extent.

Here at Williamson we were sorry indeed to see the Institute of Operating Engineers pass out of existence, and anything *Power* through its columns can do to restore this very worthy organization, will I believe be more than repaid for the time and effort put into the work in the benefit to the operating engineers of America.

Operating engineering is considered here as one of the important trades and a field offering excellent rewards to the faithful student and sincere worker. I feel that you are presenting a very important subject in connection with American industrial development, and it is our hope that a greater interest may be taken on the part of our power-plant executives in this subject of the proper training of power-plant engineers.

James A. Pratt,
Williamson School P. O., Penn. Director.

Alarm When Oil Pail Is Full

The illustration shows an alarm intended to prevent waste of oil from the receptacle overflowing. The material necessary for the construction of the device may be found in almost any plant and consists of the following: 1 board about 18 in. long by 12 in. wide and 1 in. thick, a 2½-in. No. 8 wood screw, 1 strap hinge, 1 small screw hook and eye and 1 curved spring

PLATFORM LOWERS WHEN WEIGHTED, CLOSING CIRCUIT

as shown. Wood cleats are nailed to the board, so that the pail will always be placed in the same position. The screw can be adjusted so contact can be changed to suit pails of different size. The number of quarts or gallons can be easily tallied by adjusting the contact screw for an even number of quarts.

Fall River, Mass. Thomas P. Caden.

Accident in Water-Power Plant

An unusual accident happened in one of our far Western hydro-electric plants some time ago. One of the blades of the fan on the shaft of a 2300-volt alternator broke and was thrown into the windings of the stator, injuring the insulations and causing them to burn out. The service was interrupted only for about twenty minutes, however, while a reserve unit was being put into service. Ed. M. Keys, Jr.

Montesano, Wash.

An Experiment with a Float

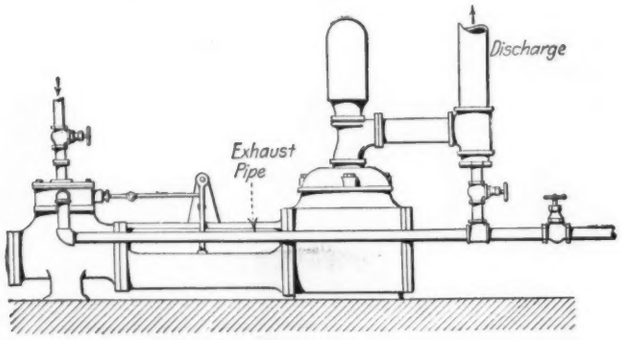
An interesting experiment can be tried in the following manner, and it may be the solution of the trouble from floats collapsing under high pressure. Take an ordinary tin can and put just the right amount of water into it, solder it up tight and put it inside of a boiler or other steam-pressure vessel. If the right amount of water has been put in, the can will not collapse or burst; otherwise it will be found in one condition or the other when the boiler is again opened.

Dig up your steam tables and figure out how much water to put into a can of a given size to keep the pressure inside equal to that on the outside of the can.

New York City. J. LEWIS.

Keeping Exhaust from Freezing

Referring to Mr. Bertrand's letter in the issue of May 1, page 608, "How Can the Pump Exhaust Be Kept From Freezing," I will say that such cases have been successfully overcome by piping the exhaust of the pump directly into the water-discharge pipe with an arrangement of valves so as to have the pump exhaust to the atmosphere on starting. The two points in favor of this system are doing away with the usual noise of the exhaust and the freezing effect.



AIR EXHAUSTED INTO PUMP DISCHARGE PIPE

This may be an old method, but if Mr. Bertrand wishes to cut out the use of steam, I believe he can do so by this means. I hope he will try this "stunt" and let us (readers of *Power*) profit by his experience.

Burke, Idaho. ART DUBE.

[See an article in *Power*, Jan. 21, 1908, where the exhaust air is introduced into the ascending column of water in such a way as to form an air lift.—Editor.]

Field Coils Heated When Switch Was Left Closed

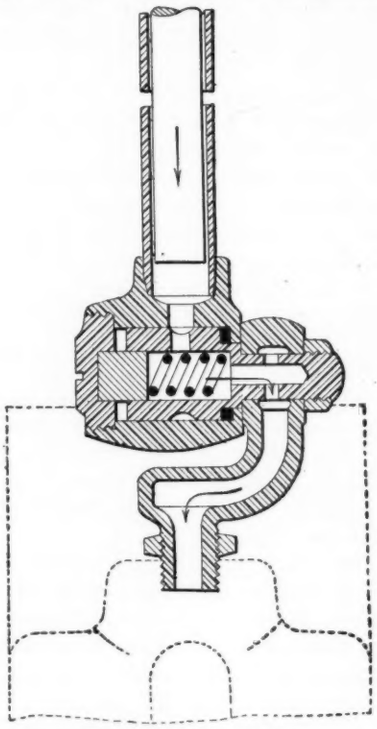
Referring to the article on page 830 of the June 19 issue of *Power*, entitled, "Could Not Pry Engine Off Center," by Thomas M. Gray, I once had a somewhat similar experience from the field switch being left in on a 360-kw. unit after it had been paralleled with another 500-kw. machine.

Both units received their excitation from the same motor-generator set, and after the 360-kw. unit's oil switch was opened and the engine shut down, no one noticed that the field switch had been left closed until about four hours later. We began to smell burned insulation and upon investigation found the field coils on the 360-kw. machine very hot. This apparently did not injure the coils, as the unit has been in service five years since the occurrence and no trouble has been experienced from the field coils. H. I. REEDER.

Emporia, Kan.

Telescopic Oiler Discussion

I did not know that I was going to start such a lengthy discussion when I brought up the subject of using telescopic oilers on engines. While the majority of those who have taken part in the discussion approve the telescopic oiler, properly designed and installed, it has been objected (1) that there is some liability of the



TELESCOPIC OILER

oiler giving a pumping action and feeding too much oil and (2) that difficulties are experienced in keeping the knuckle joint tight.

The first objection is easily overcome by having sufficient clearance between the inside and outside tubes. The second objection has been overcome in the telescopic-oiler joint that we are using by providing it with an internal spiral spring, as shown in the accompanying section, which keeps the two halves of the joint snug up against the fiber washer. Thus, as wear occurs, it is automatically taken up, and we have found that this type of oiler is free from leakage at the joint.

GEORGE F. FENNO,
Milwaukee, Wis. The Richardson-Phenix Co.

The temperature of a boiler tube is within 20 to 35 degrees F. of that of the boiler water, and the temperature of the tube is affected very little by the temperature of the hot gases, but follows the temperature of the water in the boiler.—*A. S. M. E. Journal.*

Inquiries of General Interest

Leading Side of Duplex Pump—In an ordinary duplex pump with lost-motion D slide-valve gear, which side is the leading side? G. L.

The leading side of the pump is the side on which the piston rod is connected to a rocker-arm that is on the same rocker-shaft with a valve-rod crank which points in the same direction.

Relative Point of Cutoff in Vertical Engine—On a vertical engine should the cutoff be later on the upward or on the downward stroke? W. E.

To compensate for raising the weight of the reciprocating parts, the total expansive force of the steam acting on the piston should be greater on the upward stroke, and with due allowance for reduction of piston area from presence of the piston rod, usually from the under side of the piston, there should be greater average pressure per square inch, requiring a later point of cutoff, for the upward stroke.

Movement of Eccentric Rod—Where the shaft diameter is 15 in. and the eccentricity of the eccentric is 5 in., how much would the eccentric rod be moved lengthwise if the eccentric is turned ⅛ in. around the shaft? H. L. S.

The amount of movement would depend on the initial angle of the eccentric with the rod. If the initial angle is 90 deg., then, as the eccentricity is 5 in. and radius of shaft 7½ in., the movement would be practically $\frac{5}{7.5}$ of ⅛ = ⅓ in. If the initial angle is zero—that is, if the eccentric is at dead-center—then the movement would be practically zero.

Magnetic Wedges—Why are metal instead of wooden or fiber retaining wedges sometimes used to hold the coils in the stator slots of induction motors? A. A. F.

With semiclosed stator slots, a given induction motor will have a higher power factor than when designed with open slots. Open-slot cores are much easier to wind and insulate than semiclosed slot cores. Therefore, to obtain the advantage of the semiclosed slots in the open-slot cores, metal wedges, usally known as magnetic wedges, are used. One form consists of two pieces of steel held against the sides of the slot with a center brass piece, and these wedges are insulated from the core to avoid short-circuiting the teeth.

Diameter of Water Cylinder for Greater Pressure—A pump having a steam cylinder 6 in. in diameter and a water cylinder 5 in., when supplied with steam at 70 lb. pressure, obtains a hydrostatic pressure of 90 lb. per sq.in. What should be the size of water cylinder to obtain a pressure of 140 lb. per sq.in.? J. P. D.

For the same steam pressure and same loss from friction in each case, the hydrostatic pressures obtained will be inversely as the cross-sectional areas of the water cylinders or inversely as the squares of their diameters. Hence the square of the required diameter would be $90 \times 5^2 \div 140 = 16.07$, and the diameter would be $\sqrt{16.07}$, or about 4 in.

Variation of Cutoff for Same Reduction of Load—For the same reduction of the load, why is there less variation of the cutoff in a single-valve automatic engine than in a Corliss engine? S. R. D.

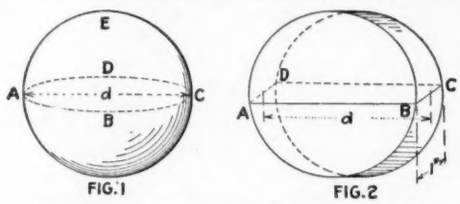
In the single-valve automatic engine the governor effects a reduction of the mean effective pressure, corresponding with a reduction of the load, by shortening the cutoff and increasing the compression of the exhaust. In the Corliss engine, back pressure of the exhaust and compression are practically constant and the governor controls the required variation of mean effective pressure solely by varying the cutoff, so that, other things being equal, the same variation of load requires the governor of the automatic engine to provide for less variation of the cutoff.

Percentage of Forcing Boiler Above Rated Size—A horizontal return-tubular boiler containing 1000 sq.ft. of heating surface is supplying 5000 lb. of steam per hour at a pressure of 125 lb. gage, from feed water at 200 deg. F. What percentage is the boiler forced beyond usual rating of a boiler of the size? P. T.

According to the usual standard for builder's rating, which allows 10 sq.ft. of heating surface per horsepower, the rated size of the boiler would be $1000 \div 10 = 100$ hp. The usually accepted unit of boiler-horsepower performance is the equivalent of evaporation of 34.5 lb. of water per hour from and at 212 deg. F. Each pound of water so evaporated requires the latent heat of evaporation, or 970.4 B.t.u. A pound of steam at 125 lb. gage, or 140 lb. absolute, contains 1192.2 B.t.u. and with feed water at 200 deg. F. each pound of water evaporated under the actual conditions would be equivalent to the evaporation of $\frac{1192.2 - (200 - 32)}{970.4} = 1.055$ lb. of water from and at 212 deg. F. Therefore the actual performance would be $\frac{5000 \times 1.055}{34.5} = 153$, or 53 per cent. above the rated size of the boiler.

Stresses in Spherical and Cylindrical Shells—Why is the stress per square inch of cross-section of a spherical shell one-half as great as the hoop stress per square inch of cross-section of a cylindrical shell of the same diameter and thickness, when both are subjected to the same internal pressure per square inch? J. W. M.

In each instance, calling d = the diameter, t = the thickness and p = the pressure in pounds per square inch, then



SPHERICAL AND CYLINDRICAL SHELLS

in the case of the spherical shell, Fig. 1, the total pressure tending to separate any hemispherical portion of the shell like $ABCDE$, from the opposite hemispherical portion, would be equal to the area of a great circle $ABCD$, in square inches, multiplied by the pressure per square inch, or $3.1416 \times \frac{1}{4}d^2 \times p$, and as the circumference, in inches, would be $3.1416 \times d$ and cross-sectional area would be $t \times d \times 3.1416$, the stress per square inch of the material would be

$$\frac{3.1416 \times \frac{1}{4}d^2 \times p}{t \times d \times 3.1416} = \frac{1}{4} \text{ of } \frac{dp}{t}$$

In the case of a cylindrical shell, as in Fig. 2, having a diameter = d, for a length of shell = 1 in., the total pressure tending to separate the upper half from the lower half would be equal to the area $ABCD$ in square inches multiplied by the pressure in square inches, or $d \times 1 \times p$. The hoop stress at AD or BC would be one-half as much, or ½ of dp, and for a thickness t the stress per square inch of the material would be ½ of $\frac{dp}{t}$, or twice as much as for a spherical shell of the same diameter and thickness.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Development of the Poppet-Valve Engine*

BY S. ROSENZWEIG
Consulting Engineer, New York.

The first Sulzer engine is still the standard design of modern poppet-valve engines. The many advantages of superheated steam as used in poppet-valve uniflow engines is discussed. Dwells on the application of poppet valves in marine, locomotive and locomobile service.

TO meet competition with other prime movers, still greater demands have in recent years been made upon the steam engine. The design had to be modified to adapt it to other increasing steam pressures, superheat, and rotating speeds with correspondingly increased piston speeds. The improvements made in the preparation of material and in shop practice, and also the better conception of the actual working conditions existing in a steam engine, greatly aided and encouraged the efforts of progressive designers.

The poppet-valve engine, or at least an engine of similar construction, seems to be destined to play the leading part among steam engines.

The first Sulzer engine became, and still is, the standard design of modern poppet-valve engines. While the Corliss engine was finding great favor in this country and also in England and France, engineers in Germany, Austria and Switzerland pinned their faith to the poppet-valve engine, convinced that with the advent of higher steam pressures and higher steam temperatures in general the poppet valve was more suitable than other kinds of valves. Present practice demonstrates that these engineers displayed sound judgment.

The author here quotes from a paper on higher steam pressure by Robert Cramer before the American Society of Mechanical Engineers, December, 1915. This paper appears in *Power* for Dec. 14, 1915, p. 843. (See also Feb. 13 issue of *Power* for opinions of distinguished engineers on higher pressures and superheat.) If one considers that superheating steam means raising its temperature above that due to its pressure, it is obvious that condensation cannot possibly take place until all superheat has disappeared. Furthermore, being a poor heat conductor on account of its density, it retains its heat better and longer and does not give it up as readily as dry-saturated steam. This property becomes more marked as the superheat increases.

Professor Doerfel, of the University of Prague, Austria, found that by increasing the superheat from 46 to 256 deg. F., the loss during the admission period decreased about 8400 to 1900 B.t.u. These experiments were confirmed by Semann, who found that with dry-saturated steam the heat given up to the cylinder walls was 36.2 per cent. and decreased to 9.3 per cent. when the steam was superheated to 360 deg. F.

Of very great importance is the prevention of leakage past valves and pistons. Longridge, before the Institution of Mechanical Engineers in England, July, 1904, contended that with fluids of low viscosity, such as steam and water at high pressures, the velocity of flow through a small orifice, such as might be supposed to exist between a valve and a space, would depend almost entirely upon the difference of the pressure, and would therefore be practically equal under a given pressure. As the density of water is so much greater than that of steam, it is easily seen that the weight of water leaking past a valve under a given pressure would be 1600 times the weight of steam.

The introduction of superheat naturally makes superfluous the distribution of expansion over several cylinders. Triple- and quadruple-expansion engines, so much in favor about ten years ago, were gradually abandoned and successfully replaced by compound engines. The trend today is for single-cylinder engines, using highly superheated steam. The simplification in cylinder arrangement has produced a great saving in the initial cost, floor space and operating cost.

The last ten years of the last century brought forth the excellent superheater constructions of Schwoerer, of Elsace, and the engine and superheater designs of Wilhelm Schmidt. Schmidt attracted universal attention when in 1895 he successfully utilized steam temperatures up to 650 deg. F. in reciprocating engines of his own design.

The author here dwells upon the merits of the uniflow engine, such as the great reduction of the losses through cooling action of the cylinder walls by reëvaporation, and the further advantages due to the fact that the clearance

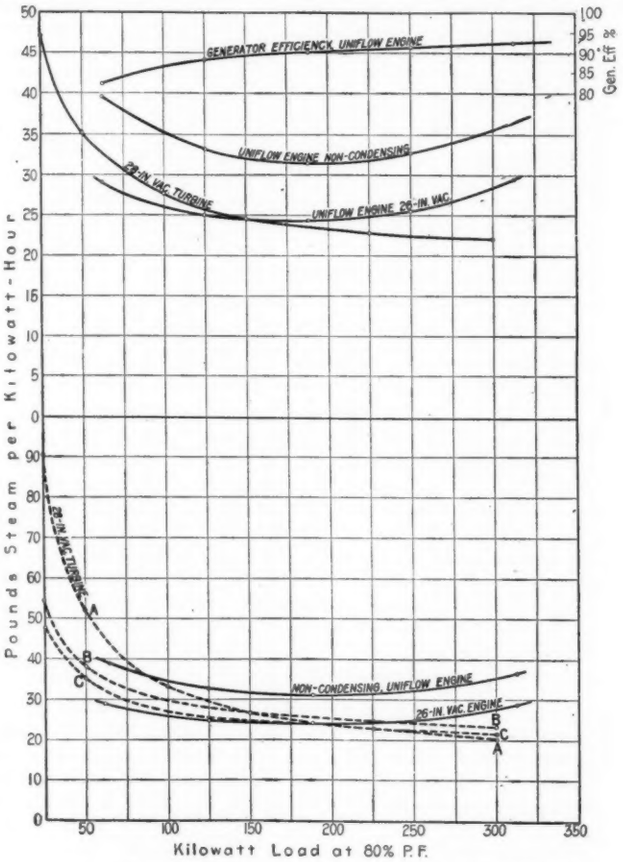


FIG. 1. SHOWING PERFORMANCES OF UNIFLOW ENGINES AND OF TURBINES

surfaces and volumes are considerably reduced as the exhaust valves of the usual type are eliminated. Again, there is the advantage of the reduction of leakage loss through the exhaust port.

The author enumerates the advantages of the uniflow engine as follows:

1. Steam enters at one cylinder end and exhausts at the other, leaving the hot end hot and the cold end cold, and avoids clearance losses.

2. Elimination of the exhaust valves with the large clearance surfaces and volumes.

3. Large central exhaust ports of about three times the area of those provided in standard engines. Prevention of leakage past exhaust valves and the piston. Flat steam-consumption curve for all loads above and below normal.

An interesting comparison is afforded by the guaranteed steam consumption of small turbines and uniflow engines

*Excerpts from a paper presented before the American Society of Mechanical Engineers, New York City, May 8, 1917.

for the new $3,000,000 pumping station of the City of Cleveland, Ohio, as represented by diagrams, not published herewith, but which appeared in *Power* for June 6, 1916. The equipment consisted of an engine driving a 100-kw. generator at 80 per cent. power factor; the steam conditions specified were 200 lb. gage pressure, 100 deg. F. superheat, 2 lb. gage back pressure when running noncondensing, and a vacuum of 26 in. for the engine, 28 in. for the turbine, when operating condensing. L. A. Quale, mechanical engineer of the Cleveland Water Department, describing the performance of these engines in *Power* for the date mentioned, says: "The pressures and economy guarantees received on bids from two engine and three turbine builders, as well as informal bids received from two other companies, one a turbine and the other an engine builder, have been used in making the comparison given here. The pressures and guarantee curves represent only the average of the three makes of engines and the four makes of turbines, including three different makes of generators, all of the bidders being well-known. It is felt that the economy guarantees are conservative, as there was a penalty of $7 per pound of steam per kilowatt-hour for failure to meet the guaranteed economy, and no bonus was offered for exceeding the guarantees."

Figs. 1 and 2 show performance curves for uniflow engines, and are from the author's paper.

The author here goes into a very detailed description of the constructional features of poppet-valve engines, including those of the uniflow type, as applied to such services as marine, locomotive, stationary and locomobile. As space does not permit the publication of this part of the paper complete, the reader is referred to the paper.

Considerable space is devoted to compression in uniflow engines. It is stated that in the standard type of uniflow engine compression takes place during approximately 90 per cent. of the stroke, and for this reason provision has to be made to overcome excessive compression in case the engine is operated at such back pressures as to cause the final compression pressure to exceed the steam pressure. How this is overcome by designers of this type of engine is described in detail. Referring to Professor Stumpf's book, "The Uniflow Steam Engine," the author gives the following:

"The constant compression always held to be a desideratum in large engines is fundamentally false. It further follows that the distribution obtained by link motion and shifting eccentric gear is fundamentally correct, as it gives large compressions with early cutoffs and small compressions with late cutoffs." To what extent the 90 per cent. compression in uniflow engines exceeds the most economical compression can be seen from diagrams (not given) replotted from the book of Professor Stumpf. For example, an engine working with 170 lb. gage pressure, 197 deg. F. superheat, 29 in. vacuum, and a cylinder clearance of 2 per cent., the most favorable compressions for different cutoffs, as taken from this diagram, are as follows:

Per Cent. Cutoff	Per Cent. Compression
10	70
15	59
20	50
25	45

Speaking of the locomobile, Mr. Rosenzweig states that this type of machine was originally developed in England in portable and semiportable outfits and was probably, in design and construction, the cheapest kind of machinery available, as remarkable economies have been obtained with these engines. Steam consumptions of 8 lb. and coal consumptions of 1 lb. per i.hp.-hr. in units of 100 to 200 hp. are not unusual in compound engines, and with working conditions not exceeding 200 lb. pressure and 300 deg. F. superheat. Though these engines are particularly attractive in the small sizes, say up to 300 hp., a Lentz locomobile of 1000 hp. has been built.

Two very interesting tests carried out on locomobiles are given here:

Steam pressure, lb. gage	213	432
Temperature high-pressure steam, deg. F	923	1018
Indicated hp	112	99
R.p.m.	150	158
Vacuum, in.	27.7	26.7
Steam consumption per hp.-hr. lb.	6.53	5.68
Heat consumption per hp.-hr., b.t.u.	9720	8640

It is interesting to note in comparison tests on the White steam engine, such tests being made by Professor Carpenter, of Cornell. The steam pressure was 427 lb., the steam temperature 767 deg. F., operating noncondensing, and an economy of 12.29 lb. per b. hp.-hr. was obtained.

To ascertain the advantages of superheated steam in poppet-valve engines in steamships, the Compagnie Generale Transatlantique, of France, ordered in 1905 from the navy yard of Saint-Nazaire, two cargo boats—the "Rance," the two boilers of which were fitted with superheaters and the engine with poppet valves; and the "Caronne," fitted with the ordinary type of marine engine without superheater. Tests were made under identical conditions and showed that, owing to the superheater and poppet-valve engines, an increase of power of 18.1 per cent. and a decrease in coal consumption of 20.1 per cent. were obtained.

The first company to equip locomotives with poppet valves was the Hannoversche Maschinenbau, of Hanover, Germany. Preliminary tests were made in 1905 on an old tank locomotive that happened to be in the shops of this company undergoing repairs. The tests were made after the old slide-valve cylinders were replaced by cylinders fitted with poppet valves and Lentz gears. The results were highly satisfactory to advocates of poppet valves and

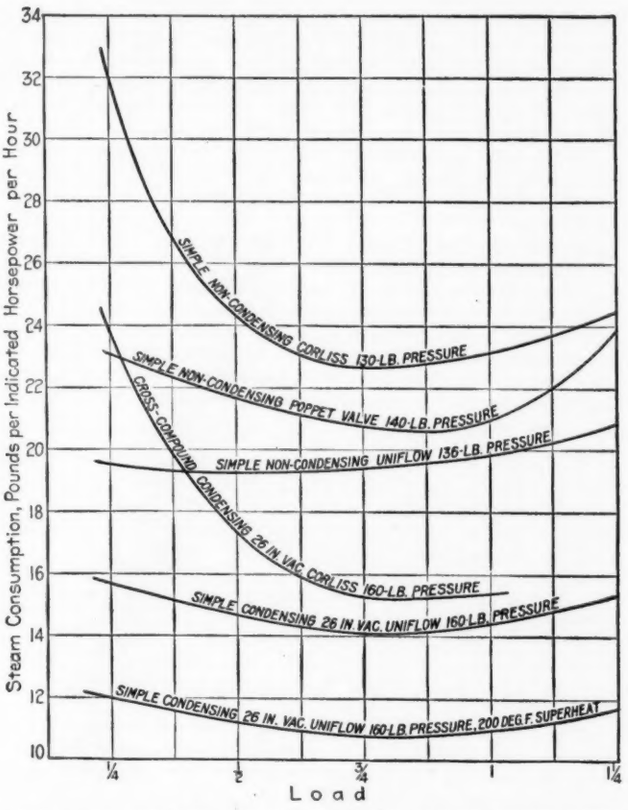


FIG. 2. UNIFLOW ENGINE PERFORMANCE COMPARED WITH THAT OF OTHER ENGINES

superheaters on locomotives, as with a steam temperature of 520 to 540 deg. F., the poppet-valve locomotives showed a saving in water consumption to the extent of 30.6 per cent., and a saving in coal of 19.5 per cent., as compared to the slide-valve locomotive working with saturated steam.

The uniflow engine on locomotives has shown good results and seems to give better results with the return-flow poppet-valve engine at light and medium loads, while the superiority seems to rest with the latter type on the heavy loads.

It is difficult to say how many poppet-valve locomotives are in service now, but according to the author's information there were several hundred in operation in Germany before the war, and many in England, France, Belgium, Austria, Switzerland, Russia and the Scandinavian countries.

Operating Characteristics of Federal Buildings

Before the recent convention of the National District Heating Association at Detroit, Nelson S. Thompson delivered an interesting paper dealing with the operating characteristics of the Federal buildings in Washington, D. C., in connection with the design of the central heating, lighting and power plant.

The estimated amounts of steam used by the occupied buildings were determined from the coal burned for each building, on the basis of an evaporation of 8.62 lb. of water per pound of bituminous coal, or 6.38 lb. of water per pound of anthracite (mostly pea coal). These evaporation figures were obtained as the result of trials extending over a period of two weeks, one on a set of boilers equipped for burning anthracite, and the other on boilers equipped for burning bituminous coal. Car-mile recorders were used on the elevators and revolution counters on the elevator pumps. The amount of electric current was readily obtainable in each case from the building records. The operating characteristics of the uncompleted buildings were estimated, in accordance with the practice of the writer, as follows:

The total cubic contents of the average Federal building multiplied by 4 is assumed to equal the total pounds of steam per annum for heating and ventilating the building. The average demand for steam per hour for heating and ventilating equals the annual consumption divided by 5000. The maximum demand for steam per hour for heating and ventilating is 2½ times the average demand.

If the heating surface is known, the blast coils are reduced to equivalent direct radiation by multiplying the square feet of heating surface in blast coils by 3; and after all surface is reduced to equivalent direct steam radiation, to ascertain the total steam required per annum, the number of square feet equivalent direct steam radiation is multiplied by 500. This is used as a check on the first assumption, and the mean of the two quantities is generally taken.

Gravity indirect water or steam radiation is reduced to equivalent direct water or steam radiation, as the case may be, by multiplying by 1½. To reduce direct hot-water radiation to the direct steam equivalent, it is divided by 1.6.

Requirements of Elevator Service

Car-miles per day for each elevator in an ordinary small Federal building are taken at 5; while in the large buildings of six or eight stories in places like New York and Philadelphia, and in the departments at Washington, each passenger elevator will average 10 car-miles per day.

Kilowatt-hours per car-mile for electric elevators equal 5. Steam per car-mile for hydraulic elevators operated by compound duplex steam pumps equals 1000 lb.; while for high-duty pumps it amounts to 650 lb. Steam per annum used for heating water for sanitary purposes is 10 per cent. of the total steam used for heating and ventilating the building.

For a post-office building (a 24-hour activity) the annual current consumption, in a modern large Federal building, will average 2½ kw.-hr. per sq.ft. of total floor area; while in a large modern Federal building of 8-hour activity it will average 1¼ kw.-hr. per sq.ft. In Federal buildings of 1,000,000 cu.ft. contents or smaller, with 24-hour service and electric elevators, the current consumption per annum will average 0.8 kw.-hr. per sq.ft. total floor area.

The average demand for electric power and light will be the total annual consumption divided by 8760, and the maximum demand will be 2½ times the average demand in a 24-hour building and 4 times the average in an 8-hour building.

If an electric generating plant is installed in a building, using high-grade four-valve engines, 50 lb. of steam is allowed for each kilowatt-hour at the switchboard, with no allowance for the exhaust into the heating system. This is done to cover fully all the losses incident to a modern small plant.

To reduce the pounds of steam to coal, as previously indicated (covering all losses in the plant), an average evaporation of 8 to 1 is assumed for bituminous coal and 6 to 1 for anthracite pea or buckwheat.

Boiler-room repairs per year average $1 per horsepower of nominal boiler rating. Engine-room repairs average $1 per kilowatt of nominal total kilowatt rating of the generators. Boiler- and engine-room supplies are placed at $2 per kilowatt of the rating of the generators installed.

Boiler-room labor averages $2 per ton of coal fired, based on 8-hour shifts and an average wage per day of $2.50 for each fireman. In the smallest generating plants one chief engineer at $1400 and three assistant engineers at $1200 each per annum must be provided, and in the larger plants the salaries are increased and additional labor supplied. The labor in a Federal building containing an electric generating plant will roughly average the same as the cost of the coal, supplies and repairs to the boilers and electric generating plant.

The fixed charges are those sanctioned by the Bureau of Standards for machinery in Federal building, that is, 3 per cent. interest and 5 per cent. depreciation per annum on engines, boilers, etc.; while on buildings, tunnels, [illegible] walls, cables, etc., 2 per cent. depreciation per annum is allowed.

The annual dividend that must be earned by the ordinary isolated plant in comparison with the purchase of current from a public utility is 6 per cent. on the cost of the Government plant.

From the records of eighteen large buildings scattered over the entire United States, it is found that the average of the steam consumption per month for heating is as follows:

	Per Cent.		Per Cent.
October	6	February	18
November	11	March	15
December	18	April	10
January	18	May	4

Application of the foregoing data to a few of the buildings to be served by the central heating, lighting and power plant, and to one where steam and electricity are now purchased, showed that the approximations noted were fairly accurate. Data from the District Building only are presented in the following:

Cubic contents, 4,600,000 cu.ft. A small portion of the building is used 24 hours a day for police headquarters. The building is equipped with electric generators, and all fans, etc., are electrically operated.

Kilowatt-hours generated per annum in the isolated electric generating plant, 436,000. Total square feet floor area, 325,000.

Steam for heating and ventilating on cubic-contents basis equals $4{,}600{,}000 \times 4 = 18{,}400{,}000$ pounds.

Steam for heating and ventilation on the equivalent direct-steam-radiation basis equals $40{,}000 \times 500 = 20{,}000{,}000$ pounds.

Averaging the two foregoing items gives 19,200,000 lb. as the steam for heating and ventilating.

Steam used to generate electricity equals $436{,}000 \times 50 = 21{,}800{,}000$ pounds.

Steam for heating water for sanitary purposes is 10 per cent. of 19,200,000, or 1,920,000 pounds.

Total steam for all purposes, 42,920,000 pounds.

The survey shows 38,617,000 lb. based on coal actually burned, using the evaporation factor of 8 to 1.

Maximum demand for steam for heating equals $\frac{(19{,}200{,}000 + 1{,}920{,}000)}{5000} \times 2\frac{1}{2} = 10{,}560$ pounds.

Maximum demand for electricity, $436{,}000 \div 8760 \times 4 = 200$ kilowatts.

Steam from the 200 kw., $200 \times 50 = 10{,}000$ lb., less 20 per cent. for condensation, or 8000 lb. available for heating. Thus the boilers must generate practically 2000 lb. more steam to heat the building, or 12,000 lb. per hour for electricity and heating.

Maximum demand on the boilers then equals $12{,}000 \div 30 = 400$ hp., which is close to the rule of Arthur Williams, of the New York Edison Co., of one boiler horsepower per 10,000 cu.ft. of building.

Total coal burned (bituminous) $\frac{42{,}920{,}000}{8 \times 2240} = 2400$ long tons.

The coal actually burned was 2010 long tons.

Total floor area in square feet, 325,000, $\times 1\frac{1}{4} = 406{,}250$ kw.-hr. demand.

Average demand, 406,250 ÷ 8760 = 46 kilowatts.
Maximum demand, 46 × 4 = 184 kilowatts.

There was actually used in the building 436,000 kw.-hr. per annum, the measured average demand was 50 kw., and the measured maximum demand was 222 kw., with a maximum surge of 300 kw. due to electric elevators.

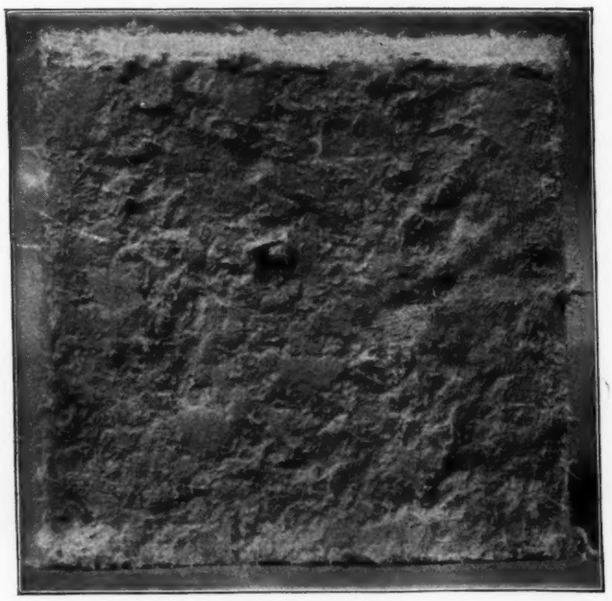
The smaller buildings in the group of the typical office-building class followed closely the writer's approximations.

Durability of 85 Per Cent. Magnesia

In a recent paper before a meeting of the Magnesia Association of America at Philadelphia, Dr. Richard V. Mattison discussed some points of interest in the selection of heat-insulating covering for pipes and boilers, and touched upon the condition of 85-per cent. magnesia as found after long use on the piping of several well-known power plants.

In specifying the insulating covering for pipes and boilers, the doctor pointed out two questions of vital importance—the heat-conserving properties of the material and the lasting qualities. The importance of the first is easily appreciated, since the resultant saving in coal and increased efficiency of the steam plant will soon pay for any difference in first cost. The answer to the second can best be found from recorded experience.

When the late Henry G. Stott made his famous series of tests covering 21 of the best-known, and some almost unknown, commercial heat-insulating materials, he decided upon 85-per cent. magnesia as most fully complying with the heat-insulating requirements of the large power plants of the New York Interborough Ry. The whole story of these tests was reported in *Power* for December, 1902. His conclusions were based on the following considerations: (1) Investment in nonheat-protecting covering as a matter of economy; (2) cost of coal required to supply lost heat; (3) 5 per cent. interest on capital invested in extra boilers and stokers required to supply lost heat; (4) guaranteed life



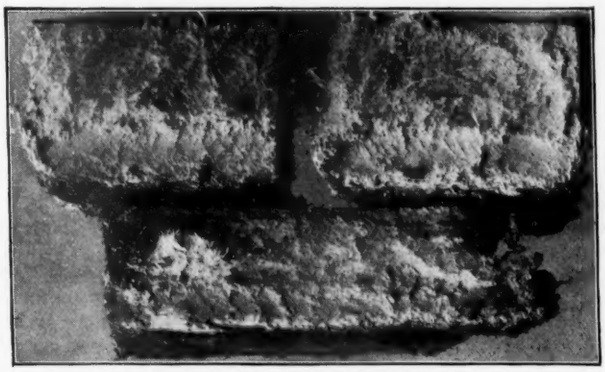
NEW BLOCK OF 85 PER CENT. MAGNESIA, SHOWING APPEARANCE BEFORE APPLICATION

of covering selected; (5) thickness of covering required for economy of service in relation to its first cost.

The coverings selected by Mr. Stott are still in daily use and appear fully as efficient as they were 15 years ago.

For practical purposes it seems generally agreed that a maximum temperature of 700 deg. F. is not likely to be exceeded for many years to come (see *Power*, Feb. 13, 1917). Before still higher temperatures are adopted in general practice, a revolution must take place in the construction not only of boilers, but piping, valves and even the designs of engines themselves, involving the composition of the very metal from which they are constructed.

While nothing is final and mechanical science may perhaps triumph over these, it seems certain that for some years to come 600 deg. F. will represent the limit of practical working in at least 95 per cent. of the steam plants of the country, and at this and even higher temperatures up to 1000 deg. F., 85-per cent. magnesia, according to Doctor Mattison, will retain its insulation efficiency without deterioration over a period of many years, coverings applied 25 years ago still



BLOCK REMOVED AFTER 3 YEARS OF SERVICE AT 480 DEG. F.

being in active service. In some cases the old pipe lines were replaced by new, the covering removed and used again on the new pipe. Of course it is not a refractory material suitable for furnace temperatures; it is intended as a covering for steam pipes and boilers.

It is told by George W. Stetson, of Boston, a dealer in power-plant equipment, that during 1903 and 1904 the Bay State Railway Co. built a large power station at Quincy Point, Mass. Eighty-five-per cent. magnesia was used exclusively throughout the station. At the time the contract was placed it was claimed that on account of the high temperature of the steam in the main, the covering would deteriorate rapidly. The covering on the main header behind the boilers consisted of 2-in. blocking, joints being filled with 85-per cent. magnesia cement and finished with 1-in. thickness of 85-per cent. magnesia having sewed canvas jackets. The total thickness of the covering was 3 in. The steam pressure on the header averages 175 lb. with about 100 deg. superheat, so that the total temperature has averaged about 480 deg. for 13 years. The covering was removed from this header and pieces of blocking that had been in contact were taken off. They were found to show no deterioration, as may be seen by the accompanying photographs, which also show a section of new covering for comparison, there being no apparent difference.

Had the sides of the blocks next to the header, where the heat was greatest, shown deterioration, it would have indicated that the contact side only had suffered, but as a whole, inside and out, the block was good. The fact that the contact side was as good as the rest of the block indicated further that exposure to even a higher temperature would not have damaged the covering enough to impair its efficiency.

The foregoing is further substantiated by E. R. Weidlein, associate director of the Mellon Institute, Pittsburgh, who, in a recent interview, said that he had personally kept 85 per cent. magnesia in service exposed to the weather under a temperature higher than 600 deg. for more than a year.

Coming down to notable recent installations in which this covering is used, Doctor Mattison mentioned the new Boston "Tech," where over twenty miles of magnesia covering has been installed, and the equally noteworthy River Station of the Buffalo General Electric Co. Among other users mentioned were the Bethlehem Steel Corporation and the United States Navy, which employs this covering almost exclusively on its naval vessels ranging from the dreadnaught down to the smallest tug.

Modern War a Matter of Mechanics and Engineering

BY E. W. RICE, JR.
President, General Electric Co.

The war problems that are uppermost in our minds at the present time, including the shipbuilding program, the solution of the submarine menace and the airplane, were discussed from an engineering standpoint by Mr. Rice, on accepting the presidency of the American Institute of Electrical Engineers, for the year 1917-18.

IT has been asserted many times that modern war is largely a question of mechanics and engineering, a statement with which we must all agree. It is therefore self-evident that engineering must take a leading and dominant position in the war work. Now the electrical engineer stands for about the latest thing in engineering development; his activities embrace practically all other fields of engineering, being, so to speak, the last word in engineering. The electrical engineer must therefore realize that this is his war in a very personal and particular sense.

War calls for supreme sacrifices and the deepest devotion, but it also demands something more difficult to give, and that is *work*. War may be said to be the personification of work—not only individual work, but especially organized and disciplined work—disagreeable, dirty, heartbreaking, back-breaking, nerve-racking work, but always work. No nation of loafers ever won a war. Other things being at all equal, that nation or people who are willing to work the hardest will surely win the victory.

Our enemy boasts that we have started too late. We must, by the hardest work directed with scientific skill and accuracy, organize and effectively utilize all our power of work to make his prophecy an idle boast.

War is a business and must be handled as a highly organized, centralized enterprise. We must, no matter how repugnant it may be to our habits and thoughts, temporarily adopt such methods of our enemy as are known to be efficient and successful, because the penalty of failure is death. The things connected with war are so repugnant to our ideas that it takes time to realize the necessity for and make the colossal changes demanded.

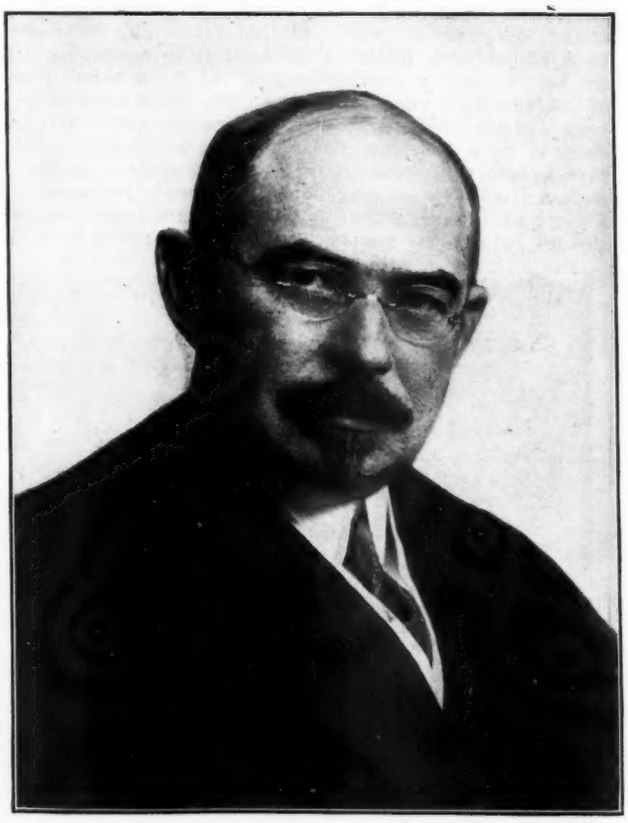
There is one idea that we must abandon. The great majority of our people, having no acquaintance with science or engineering, are prone to imagine that this war will be settled quickly by some wonderful new invention, as if by an act of legerdemain; but you engineers realize that such a thing is practically impossible. It is so hopeless that it is cruel to permit any such idea to take hold of the American public. Neither is it possible for the war to be settled by the act of some hero or superman. It can be settled only by the united efforts of thousands of men, each contributing his bit. "Team play" in our civil army at home is as essential as in our fighting army abroad.

We should put ourselves and our business in such condition as to meet whatever demand is made upon us. Only relatively few can be useful in the direct service of the army and navy, but there is plenty of honorable and useful work for us to do. The most effective work for most of us will be in the shops and offices at home, and everyone who does his tasks loyally and well is as much a factor in our organized war as the man at the front.

Now, properly understood, the fact that no single great invention is likely to be made that will win the war is no cause for discouragement. It does not mean that there will be no improvement, no new inventions, no new methods devised and put into effect. It simply means that we must not wait for the miracle that will never appear, but must get to work and energetically take advantage of all present knowledge.

Take, for example, the matter of shipping. This perhaps presents the greatest immediate problem of the war, frightfully complicated as it is by the submarine. I feel sure that it can be successfully solved if we are content to solve it by the simple, common-sense methods used by engineers and successful business men in the ordinary course of business.

We must build the greatest tonnage in the shortest time. The ships must be manned and navigated to their destination and the most efficient methods provided for docking, unloading and loading. With the situation such that the race is between shipbuilding and ship destruction, with the destruction many laps ahead, it is vitally important that ships should be loaded and unloaded with the utmost expedition. The net tonnage delivered per month is the only thing that counts, therefore ship-tons saved is worth more than ship-tons built. Quick means of loading and unloading at specially devised terminals, here and in Europe, should be constructed and put into operation. The methods are known. It simply remains to organize and apply them.



E. W. RICE, JR.
President, American Institute of Electrical Engineers, 1917-18

If an investigation should indicate that cargo ships can be built which will successfully withstand one or more torpedo attacks and which can also be provided with speed and armament sufficient to give them a good chance of fighting off and getting away from a submarine, they should be built no matter whether such ships cost more, or are less adapted for use after the war, or take a little longer time to construct than those of the ordinary type.

It is entirely within the range of possibility that such ships may prove to be the only ones that will be able to navigate the seas with any decent chance of surviving. It would seem clear that, unless the submarine is swept from the seas, it is hopeless to build a large tonnage of slow-moving, relatively small and inadequately defended ships, as the net tonnage that could be delivered by such a fleet of ships will be too insignificant to be of any material value.

Along with this defensive plan we should put into execution every practical offensive plan of attacking the submarine, such as methods of detection when submerged, methods of attack by means of destroyers, mines, airplanes and special artillery. All such methods should be, and probably are being, developed, and while no one of them will prove to be the panacea by itself, collectively they will be of the greatest value in reducing the menace. However, I think it is well to emphasize the fact that the only safe and sane plan of action is to assume that we can win only by pushing the development of all practical-looking methods of attack and defense at the same time and to the limit of our ability.

Now I am well aware that there is nothing theatrical or startling or novel in the solution suggested. For this reason it is not likely to appeal to the great nontechnical public, but there is no doubt in my own mind that it represents the scientific and common-sense method, and that if followed with patience, persistence, vigor and diligence, it will prove successful, and if successful, the war cannot be lost. All the other problems of the war—the airplane, army, navy, food, manufacturing, farming, transportation, etc.—can be successfully solved by the same scientific but simple and common-sense methods.

It is a great satisfaction to notice that this country has at last awakened to the importance of developing that great American invention, the airplane, and manufacturing it on a great scale. We should do everything to help accelerate this work. If we can get airplanes of the right kind to Europe soon enough and in sufficient quantities, experts tell us that they will do more to win the war than a large army.

I think I have said enough to indicate that there is plenty of work for engineers at home as well as abroad, in civil life as well as camp life. Engineers have a great opportunity in this way and a heavy responsibility. You have special knowledge, experience and a forward-looking point of view which the country needs, and it is your duty to see to it that you are given the opportunity to make effective use of your talents in the service of the Nation, and if you are not given that chance, you must persistently demand it until you get it, and then I feel certain that the victory will be on our side, our civilization will be saved, and the world will be made a safe place for all decent people, and those who survive will be able to turn again to the satisfaction and joy of a useful and peaceful existence.

Coal Enough for All Needs

"To run the ships and railroads, to feed the iron furnaces and furnish steam for all the manufacturing plants requires coal in greater quantities than have ever before been mined in the United States or in any part of the world. This need is being met in truly American fashion by the operators and owners of the mines and by the diggers of coal." With these words, Secretary Franklin K. Lane began his statement regarding the coal situation as reported to him by the statisticians of his department. The production of coal in the United States last year, he continued, was the greatest in the history of the country. A new record, however, was set for the first six months of this year, fully 270,000,000 tons of bituminous coal being produced since Jan. 1, thus exceeding the output of the first six months of last year by about 20,000,000 tons. Even better news is that the limit has not yet been reached, for as the railroads are able to work out to better advantage the problem of car supply and give to the mines greater facilities for transporting their product to market, the supply of coal that reaches the consumer will be in steadily increasing quantities. In the early months of 1917, because of the congestion of the railroads and the difficulties of transportation, the production of bituminous coal fell behind the high mark set in January and February a year ago. As a result of the patriotic and earnest endeavor of the railroad officials and the coal operators and representatives of mine workers who have volunteered their services to the Federal Government in this emergency, production has been speeded up within the last few months and the output of soft coal, which in May exceeded all previous records, was surpassed in June.

Despite the extra demand in this country and the urgent needs of our allies, no one with the facts before him can doubt that the coal industry, under the careful guidance of those now directing its welfare, will be able to supply all needs. The difficulty of distribution, now so great, will be intensified, however, in the coming winter months. Just as consumers of foodstuffs are being urged to eliminate all waste and to practice sensible economy, so the consumers of coal must do their share in working out the coal problem by unloading every coal car as fast as it is received, and in improving their plants so as to utilize to the fullest the heat value of the coal that reaches their bins. In stopping the coal panic and in expediting a condition of fuel sufficiency, every consumer can do his bit.

New Generating Plant of Alabama Power Co.

The Alabama Power Co., operating at Birmingham and vicinity, is arranging to inaugurate service at an early date at its new steam-power station now being erected on Baker's Creek, a branch of the Warrior River, about 25 miles from Birmingham. The initial installation will consist of a 25,000-kv.a. turbo-generator and six 1200-hp. Stirling boilers with underfeed stokers. Steam will be carried at 225 lb. and 125 deg. superheat, and current will be generated at 6600 volts. Water for condensing purposes is available from Baker's Creek and other adjacent streams.

Plans have been prepared for an open-ground coal-storage plant with a capacity of over 75,000 tons; the coal will be supplied from the neighboring mines of the Warrior district, in which the plant is centrally located. The coal-handling apparatus will comprise an aërial traveling bridge supplemented by a belt conveyor to an overhead concrete coal bunker, the former having a capacity of about 800 tons daily. The present installation is estimated to cost about $1,750,000 and the final plant over $5,000,000, including a proposed extension to effect a total generating capacity of three times the initial plant, or 75,000 kv.a.

The plant will be used as an auxiliary to the hydro-electric power plants of the company, tied in with the main system. For the most part it will carry an industrial load, furnishing power to many coal properties in the district.

The company is now building an extension to its hydro-electric plant on the Coosa River, consisting of the installation of a new fifth unit to effect a total generating capacity of 92,000 hp. for the station.

New York Edison Co. May Reduce Maximum Rate

The New York Edison Co., in a letter to the Public Service Commission for the First District of New York, has agreed to reduce its maximum rates for electricity from 7½ to 7c. per kilowatt-hour, with the understanding that if the results are of an adverse nature the company may exercise the existing option to restore the former schedule of 8c. a kilowatt-hour on Jan. 1, 1918.

The company must appear before the Public Service Commission on Dec. 3, 1917, and state if it intends to continue under the 7c. rate or return to the 8c. rate on Jan. 1, 1918. During the last fiscal year that the 8c. maximum rate was charged the company's net earnings were $5,800,000. The net earnings for the current year at the 7½c. rate have been estimated to be about $7,000,000. The Edison company states that it has no intention of going above the 8c. rate at the end of the year and that no increase will be made at all unless business conditions make it compulsory.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	July 14, 1917	One Year Ago	July 14, 1917	One Year Ago
Buckwheat	.....	$2.05—3.20	$6.00—6.75	$3.25—3.50
Rice	.....	2.50—2.65	5.20—5.85	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	.....	2.20—2.35	4.90—5.00	2.35—2.60

*No prices quoted.

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	July 14, 1917	One Year Ago	July 14, 1917	One Year Ago
Clearfields	$3.65 up	$1.10—1.60	$9.25—9.50	$4.25—5.00
Cambrias and Somersets	3.65 up	1.35—1.75	9.25—9.75	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $5.15 up, as compared with $2.75—2.85 a year ago; on cars Boston price is $9.50—11.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	July 14, 1917	One Year Ago	July 14, 1917	One Year Ago
Buckwheat	$4.00—4.15	$2.75	$4.50—4.75	$2.55—2.75
Rice	3.40—3.60	2.25	3.50—3.75	2.00—2.25
Barley	2.90—3.10	1.75	2.70—2.90	1.75—2.00

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.75—7.00	$6.75—7.00	.....
South Forks	7.00—7.25	.....	.....
Nanty Glo	7.00—7.25	.....	.....
Somerset	6.75—7.00	6.75—7.00	.....
Quemahoning	7.00—7.25	7.00—7.25	.....

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	July 14, 1917	One Year Ago	July 14, 1917	One Year Ago
Buckwheat	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	July 14, 1917	One Year Ago
Slack	$3.00—3.25	$0.80—0.90
Mine-run	3.00—3.25	1.30—1.40
¾-in.	3.00—3.25	1.40—1.50

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$3.50	$3.50	$3.00	$2.75–3.00	$2.75–3.00
Lump	3.50	3.50	3.50	3.25–3.50	3.50
Egg	3.50	3.50	3.50	3.25–3.50	3.50
Nut	3.50	3.50	...	3.25–3.50	3.50
No. 1 nut	3.50	3.50	...	3.25–3.50	3.50
No. 2 nut	3.50	3.50	...	3.25–3.50	3.50
No. 3 nut	3.50	3.50	...	3.25–3.50	.....
No. 1 washed	3.50	...	...	.....	.....
No. 2 washed	3.50	...	...	.....	.....
Mine-run	2.75	2.75	3.00	2.75	2.50–2.75
Screenings	2.75	2.75	...	2.25–2.75	2.50–2.75

Hocking lump, $3.50; splint lump, $3.50.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	July 14, 1917	One Year Ago	July 14, 1917	One Year Ago	July 14, 1917	One Year Ago
6-in. lump	$3.50	$1.50	$2.35	$1.25	$2.50	$1.00
2-in. lump	3.25	1.50	2.25	1.15	2.25	.90
Steam egg	3.50	1.50	2.25	1.15	2.25	.90
Mine-run	2.75	1.15	2.25	1.05	2.00	.90
No. 1 nut	3.50	1.50	2.50	1.25	2.25	.90
2-in. screen	2.50	.95	2.25	.85	1.75	.85
No. 5 washed	2.50	.95	2.25	.80	...	.70

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c. Rate in dispute increases all fields 15c. higher.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.50	Carbon Hill	$3.50
Big Seam	3.00—3.25	Cahaba	4.00
Black Creek	4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ark., Fayetteville—The Middle West Gas and Electric Co. plans to improve its plant. Estimated cost, $75,000.

Ga., Augusta—R. J. Edenfield, of Augusta, and W. E. Moore & Co., Engrs., of Pittsburgh, plan to spend $2,000,000 to build hydro-electric plant and will also develop power dam on Augusta Canal.

Iowa, Davenport—The Scott County Hospital will build a 3-story boiler house and laundry.

Md., Baltimore—The Consolidated Gas Light and Power Co., care of J. R. Laizaux, Monument and Constitution Sts., is having plans prepared for a 100 x 125-ft. boiler house. Estimated cost, $200,000.

Md., Baltimore—The Maryland Chemical Co. plans to build a power plant.

Md., Towson—Black & Decker Manufacturing Co., 109 South Calvert St., Baltimore, is having plans prepared for a boiler house. H. F. Doeleman, 1101 American Bldg., Baltimore, Consult. Engr.

Mass., Boston—Burgess, Lang & Co., 199 Washington St., plans to build an addition to its power house.

Mass., Taunton—The Fall River Electric Light Co. has been granted permission by the Gas and Electric Light Comrs. to carry wires over the Taunton River for the purpose of transmitting electricity. The company also plans to connect with the transmission system of the Rhode Island Power Co.

Mich., Detroit—City will build a boiler plant. H. A. Gilmartin, 232 East Jefferson Ave., Secy. Bd. Water Comrs.

Minn., Crosby—The Lynch Mines Co., of Duluth, plans to build a power plant at Crosby. Estimated cost, $80,000. T. F. Lynch, Pres.

Mont., Miles City—The Deschner Electric Co. plans to build a power plant. Estimated cost, $92,000.

Neb., Greeley—City voted $13,000 bonds to build municipal electric-light and power plant.

Neb., Pender—City plans to rebuild electric-light plant. Estimated cost, $12,000. N. Vogt, Clk.

N. J., South River—Borough Council and Bd. Pub. Wks. plan to increase the output of the municipal electric-light plant.

N. Y., Newburgh—The Newburgh Shipyards, Inc., plans to build a power house.

N. Y., Niagara Falls—The National Electrolytic Co., Hydraulic Canal Basin, has had plans prepared for a heating plant.

N. Y., Potsdam—The Hannawa Falls Water Power Co. has had plans prepared for a hydro-electric power plant to develop a minimum of 10,000 hp. F. A. Stoughton, Pres.

N. Y., Poughkeepsie—The Wallace Co., 333 Main St., plans to build a heating plant. Estimated cost, $25,000.

Ohio, Akron—The Kendall Tire Rubber Co., 325 Ohio Bldg., has had plans prepared by W. C. Owen & Co., 1900 Euclid Ave., Cleveland, for a power house. L. H. Kendall, Pres.

Ohio, Chillicothe—The Standard Cereal Co. plans to build power house.

Ohio, Cincinnati—The Union Gas and Electric Co., 4th and Plum Sts., is having plans prepared by Sargent & Lundy, Engrs., 72 West Adams St., Chicago, for a 75 x 100-ft. substation.

Ohio, Cleveland—The Cleveland Museum of Art plans to build a 59 x 99 ft. heating and service station. Estimated cost, $100,000.

Ohio, Lakewood—Board of Education will build a 1-story boiler house. Estimated cost, $10,000.

Okla., Durant—Board of Education will build a power-house and heating plant for the normal school. Estimated cost, $18,319.

Okla., Oklahoma—The Oklahoma Gas and Electric Co. recently increased its capital stock from $5,100,000 to $50,000,000 and plans to build a large electric plant and will also build an extensive system of transmission lines. H. M. Byllesby & Co., 208 South La Salle St., Chicago, Mgr.

Okla., Stillwater—The Oklahoma Agricultural and Mechanical College plans to install electrical equipment for its science hall and gymnasium armory building. Estimated cost, $20,000. Address F. M. Redlick.

Ore., Gresham—H. L. Stocker, City Engr., filed preliminary plans with the State Engineering Department at Salem for a municipal electric-light plant. Construction work will start about Sept. 1. Estimated cost, $125,000.

Ore., Marshfield—The Oregon Power Co. plans to build a power line from Marshfield to Coquille. Estimated cost, $25,000. F. E. McKenna, Supt.

Penn., Philadelphia—The De Long Hook and Eye Co., Broad and Wallace St., is having plans prepared by W. Steele & Son, Arch., 1600 Arch St., for a power plant to be built at 21st and Clearfield Sts.

Tenn., Wilder—The Albert Amusement Co. plans to build an electric plant for its light and power. W. S. Albert, Mgr.

Tex., Stockdale—City plans to build an electric-light plant.

Wash., Tacoma—The Kapowsin School has had plans prepared by Heath & Gover, Arch., National Realty Bldg., for a new power plant.

Wis., Florence—The Peninsula Power Co., of Chicago, has purchased a site and plans to build a hydro-electric plant. Address M. Sells, Florence.

Wis., Milwaukee—Pawling & Harnischfeger plans to build a 50 x 80-ft. brick and steel power house at 38th and National Aves. Estimated cost, $30,000.

Wis., Okauchee—The Wisconsin Gas and Electric Co. is building an electric transmission line from Okauchee to Ashippon to supply electricity in the latter place. The company will soon start the construction of a transmission line to extend several miles south of Ft. Atkinson to furnish electrical service to farmers in that district. A. C. Reuteler, Mgr.

Wis., Seymour—The Seymour Electric Co. recently incorporated plans to build an electric-light and power plant. Address E. P. Daniels.